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THE

EDINBURGH NEW
PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

CONDUCTED BY

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THE

EDINBURGH NEW
PHILOSOPHICAL JOURNAL.

*Inaugural Lecture, the General Bearing of the Great Exhibition on the Progress of Art and Science.** By WILLIAM WHEWELL, D.D., F.R.S., Master of Trinity.

IT seems to me as if I were one of the persons who have the least right of any to address an audience like this on the subject of the Great Exhibition of the Art and Industry of All Nations, of which the doors have so lately closed; inasmuch as I have had no connection with that great event, nor relation to it, except that of a mere spectator—one of the many millions there. The eminent and zealous men in whose wide views it originated, by whose indomitable energy and perseverance the great thought of such a spectacle was embodied in a visible, material shape; those who, from our own countries or from foreign lands, supplied it with the treasures and wonders of art; those who, with scrutinizing eye and judicial mind, compared those treasures and those wonders, and stamped their approval on the worthiest; those who can point to the glories of the Exhibition, and say, "*quorum pars magna fui;*"—those persons may well be considered as having a right to express to you the thoughts which have been suggested by the scenes in which they have thus had to live: but of these I am not one. I have been in the Exhibition, as I have said, a mere spectator. Nevertheless, the Council of the Society of Arts have done me the

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* A copy of this very important Lecture was presented to us by its illustrious author, who read it at the meeting of the London Society of Arts in the end of November 1851.

Oct.

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honour to express a wish that I should offer to you such reflections as the spectacle of the Great Exhibition has suggested to me; and, in deference to their wishes, and especially as a token of my admiration of the truly royal mind, which saw clearly, in despite of the maxims of antiquity, that there *was* such a Royal Road to knowledge, I shall venture to offer you a few remarks,—which, precisely on account of the circumstances which I have stated, may be considered as representing the views of an unconnected spectator of the great spectacle.

To write or speak the Epilogue after any great and grand Drama, is by no means an easy task. We see the confession of the difficulty in the very incongruity of the manner in which the task is sometimes attempted: as, when after the curtain has fallen upon a deep and solemn tragedy, some startling attempt at wit and pleasantry is uttered to the audience; it may be by one of the characters whose deep sorrows or lofty aims we have been following with the profoundest interest. You will, at least, on the present occasion, not have the difficulty of the task shewn *in this manner*. Nor, indeed, is it my office, in any sense, to speak an epilogue at all. Perhaps such remarks as I have to make may rather be likened to the criticism which comes after the drama. For, as you know, Criticism does come after Poetry; the age of Criticism after the age of Poetry; Aristotle after Sophocles, Longinus after Homer. And the reason of this has been well pointed out in our time:—that words, that human language, appear in the form in which the poet utters them, and works with them for his purposes, before they appear in the form in which the critic must use them: language is picturesque and affecting, first; it is philosophical and critical afterwards:—it is first concrete, then abstract: —it acts first, it analyses afterwards. And this is the case, not with words only, but with works also. The *Poet*, as the Greeks called him, was the *Maker*, as our English fathers, also, were wont to call him. And man's power of making may shew itself not only in the beautiful *texture* of language, the grand *machinery* of the epic, the sublime display of poetical *imagery;* but in those material works which supply the originals from which are taken the derivative terms which I have just been compelled to use: in the Textures of soft wool, or fine linen, or glossy silk, where the fancy disports itself in wreaths of visible flowers; in the Machinery mighty as the thunderbolt to rend the oak, or light as the breath of air which carries the flower-dust to its appointed place; in the Images which express to the eye beauty and dignity, as the poet's verse does to the mind; so that it is difficult to say whether Homer or Phidias be more truly a poet. That mighty building, then, along the aisles of which we have wandered day after day in past months, full as it was of the works of man, contained also the works of many who were truly makers;—who stamped upon matter, and the combinations of matter, that significance and efficacy which makes it a true exponent of the inward activity of man. The objects there, the symbols, instruments, and manifestations of beauty and power, were utterances,—articulate utterances of the human mind, no less than if they had been audible words and melodious sentences. There were expressed in the ranks of that great display many beautiful and many powerful thoughts of gifted men of our own and of other lands. The Crystal Palace was the cabinet in which were contained a vast multitude of compositions—not of words, but of things, which we who wandered along its corridors and galleries might con, day by day, so as to possess ourselves, in some measure and according to our ability, of their meaning, power, and spirit. And now, that season of the perusal of such a collection of works being past; those days of wonderment at the creations of such a poetry being gone by; the office of reading and enjoying being over; the time for criticism seems to have arrived. We must now consider what it is that we have admired, and why; must try to analyse the works which we have thus gazed upon, and to discover the principles of their excellence. As the Critic of literary art endeavours to discern the laws of man's nature by which he can produce that which is beautiful and powerful, operating through the medium of language, so the Critic of such art as we have had here presented to us—of *material* art, as we may term it—endeavours to discern the laws of material nature; to learn how man can act by these, operating through the medium of matter, and thus produce beauty, and utility, and power. This kind of criticism appears to be the natural and proper sequel to such a great burst of production and exhibition as we have had to witness;—to discover what the laws of operative power are, after having had so great a manifestation of what they do.

To discover the laws of operative power in literary works, though it claims no small respect under the name of Criticism, is not commonly considered the work of a science. But to discover the laws of operative power in material productions, whether formed by man, or brought into being by Nature herself, is the work of a science, and is indeed what we more especially term Science: and thus, in the case with which we have to do, we have, instead of the Criticism which naturally comes after the general circulation of Poetry, the Science which naturally comes after a great exhibition of Art: two cases of succession connected by a very close and profound analogy. That this view of the natural and general succession of science to art, as of criticism to poetry, is not merely fanciful and analogical, we may easily convince ourselves by looking for an instant at the progress of art and of science in past times. For we see that, in general, art has preceded science. Men have executed great, and curious, and beautiful works before they had a scientific insight into the principles on which the success of their labours was founded. There were good artificers in brass and iron before the principles of the chemistry of metals were known; there was wine among men before there was a philosophy of vinous fermentation; there were mighty masses raised into the air, cyclopean walls and cromlechs, obelisks and pyramids—probably gigantic Doric pillars and entablatures,—before there was a theory of the mechanical powers. The earlier generations did; the later explained that it had been possible to do. Art was the mother of Science: the vigorous and comely mother of a daughter of far loftier and serener beauty. And as it had been in the period of scientific activity in the ancient world, so was it again in the modern period in which Science *began her later* growth. The middle ages produced or improved a vast body of arts. Parchment and paper, printing and engraving, glass and steel, compass and gunpowder, clocks and watches, microscopes and telescopes, not to speak of the marvels of architecture, sculpture, and painting, all had their origin and progress, while the sciences of recent times were in their cradle, or were unborn. The dawn of the sixteenth century presented, as it were, a Great Exhibition of the works which men had been producing from the time of the downfall of Roman civilization and skill. There, too, might be seen, by him who travelled from land to land, beautiful textures, beautiful vessels of gold and bronze, of porcelain and glass, wonderful machines, mighty fabrics; and from that time, stimulated by the sight of such a mass of the works of human skill,—stimulated still more by the natural working of those powers of man from which such skill had arisen,—men were led to seek for science as well as art; for science as the natural complement of art, and fulfilment of the thoughts and hopes which art excites;—for science as the fully developed blossom, of which art is the wonderfully involved bud. Stimulated by such influences, the scientific tendencies of modern Europe took their starting impulse from the Great Exhibition of the productions of the middle ages which had accumulated in the sixteenth century; and have ever since been working onwards, with ever-increasing vigour, and in an ever-expanding sphere.

As the successful scientific speculations of the last three centuries have been the natural sequel to the art-energies of the preceding ages, so must the newest scientific speculations of our contemporaries and their successors, in order to be successful, be the result and consequence of the powers, as yet often appearing in the undeveloped form of art alone, which exist among us at the present day. And thus a great spectacle of the works of material art ought to carry with it its scientific moral. And the opportunities which we have lately had of surveying the whole of the world in which art reigns, and of appreciating the results of its sway, may well be deemed too valuable to be let slip for the purposes of that scientific speculation which is the proper sequence of such occasions. So it has seemed to those who have from the beginning taken a lofty, and comprehensive, and hopeful view of the great undertaking of which the first act is now completed; and especially to that mind which has always taken *the most* lofty, and comprehensive, and hopeful view.

And in order to carry into effect this suggestion, it has been determined that persons well qualified to draw from the spectacle the series of scientific morals which it offers, should present them to you here;—that critics should analyse for you some of the fine compositions with which you have become acquainted;—that men of science should explain to you what you ought to learn from such an exhibition of art. And it has been thought that it might not be useless that you should be reminded, in the first place, how great and unique the occasion is, and how peculiar are some of the lessons which even the most general spectator, unfit to enter into the details of any of the special arts, may draw from it.

For indeed it is obvious, at a glance, how great and unexampled is the opportunity thus given to us, of taking a survey of the existing state of art in every part of the world. I have said, that if, in the sixteenth century, an intelligent spectator could have travelled from land to land, he might, in that way, have seen a wonderful collection of the works of man in many different countries; and combining all these in his thoughts, he would have had in his mind a representation of the whole progress of human art and industry, up to the last moment, and a picture of the place which each nation at that moment occupied in the line of that progress. But what time, what labour, what perseverance, what hardships, what access to great and powerful men in every land, what happiness of opportunity, would be implied in the completion of such a survey! A life would scarcely suffice for it; a man could scarcely be found who would achieve it, with all appliances and means which wealth and power could give. He must, like the philosophers of ancient days, spend all his years of vigour in travelling; must roam in the varied regions of India; watch the artisan in the streets of the towns of China; dive into the mines of Norway and of Mexico; live a life in the workshops of England, France, and Germany; and trace the western tide of industry and art as it spreads over the valley of the Mississippi. And when he had done all this, and however carefully he had done it, yet how defective must it be at least in one point! How far must it be from a *simultaneous* view of the condition of the whole globe as to material arts. During the time that he has been moving from place to place, the face of the world has been rapidly changing. When he saw Tunis it was a barbarous state; now that he has to make up his account, it is the first which asks for a leading place among the civilized communities of the industrial world. When he visited the plains of Iowa and Wisconsin, they were wild prairie; they are now the fields from which the cereal harvest is swept by the latest improved reaping machine. When he was at the antipodes, the naked savage offered the only specimen of art in his rude club and frail canoe; now there is there a port whose lofty ships carry regularly to European markets multiplied forms of native produce and manufactures. Even if his picture be complete as to surface, what anachronisms must there be in it! How much that expresses not the general view of the earth, but the accidental peculiarities of the traveller's personal narrative! And then, how dim must be the images of the thing seen many years ago compared with that which is present to the eye! How impossible to compare the one with the other—the object now seen in age with a similar object remembered in youth! And after all, when we have assumed such a traveller—such a one as never has been—the Ulysses of modern times—seeing the cities of many men, and knowing their minds—seeing the workshops of all nations, and knowing their arts—we have but one such. His knowledge is only his. He cannot, in any clear or effective manner, communicate any large portion of it to others. It exists only for him—it perishes with him. And now let us, in the license of epical imagination, suppose such an Ulysses—much-seeing, much-wandering, much-enduring—to come to some island of Calypso, some well-inhabited city, under the rule of powerful and benignant, but plainly, he must believe, superhuman influences, and there to find that image of the world and its arts, which he had vainly tried to build up in his mind, exhibited before his bodily eye in a vast crystal frame;—true in *every minutest thread* and hue, from the sparkle of the diamond to the mighty bulk of the colossus; true to that which belongs to every part of the earth; and this, with the effects which the arts produce, not at the intervals of the traveller's weary journey, but everywhere at the present hour. And, further, let him see the whole population of the land—thousands upon thousands, millions upon millions, streaming to this sight, gazing their fill, day after day, at this wonderful vision, inviting the men of neighbouring and of distant lands to gaze with them; looking at the objects, not like a fairy picture in the distant clouds, but close at hand; comparing, judging, scrutinizing the treasures produced by the all-bounteous earth, and the indomitable efforts of man, from pole to pole, and from east to west; or, as he would learn more truly to measure, from east to east again. When we have supposed such a vision, do we not seem to have gone beyond

> "Quicquid Grecia mendax
> Audit in historiâ;"

all the wonders of that wondrous ancient Odyssean tale? And yet, in making such a supposition, have we not been exactly describing that which we have seen within these few months? Have not we ourselves made part of the population of such a charmed isle,—of the crowds which have gazed on such a magic spectacle?

But now that we have had the spectacle before us, let us consider for a moment what the vision was, and what were the reflections which it excited. We had, offered to our review, the choicest productions of human art in all nations; or, at least, collections which might be considered as representing all nations. Now in nations compared with nations there is a difference; in a nation compared with itself at an earlier time, there is a progress. There may not always be a progress in good government; there may not necessarily be, though we would gladly hope that there is, a progress in virtue, in morality, in happiness. But there always is, except when very adverse influences roll back the common course of things, a progress in art, and generally in science. In the useful and ornamental arts nations are always going forwards, from stage to stage. Different nations have reached different stages of this progress, and all their different stages are seen at once, in the aspect which they have at this moment in the magical glass, which the enchanters of our time have made to rise out of the ground like an exhalation. The infancy of nations, their youth, their middle age, and their maturity, all appear in their simultaneous aspect, like the most distant objects revealed at the same moment by a flash of lightning in a dusky night:—or we may compare the result to that which would be produced, if we could suppose some one of the skilful photographers whose subtle apparatus we have had exhibited there, could bring within his field of view the surface of the globe, with all its workshops and markets, and produce instantaneously a permanent picture, in which the whole were seen side by side. But it is not a mere picture of things which are found standing together that we have had presented to us; the great achievement was the bringing them together. You have most of you probably heard of the careful and economical critic, who proposed to reduce the extravagance of the wish of the impatient separated lovers, that the gods would annihilate space *and* time; and who remarked that it would answer the end desired if one of the two were annihilated. By annihilating the space which separates different nations, we produce a spectacle in which is also annihilated the time which separates one stage of a nation's progress from another.

An ingenious speculator of our own day, clothing these metaphysical abstractions in the form which modern science assigns to them, has shewn how we might, theoretically speaking, be, in a few instants, actual spectators, bodily and contemporaneous eye-witnesses, of all the events which have passed since man has existed upon earth. For, if we only imagine that, as the visual impressions on the vehicle of light, by which alone vision can take place, travel away from the scenes by the occurrence of which their configuration was given to them, we also travel after this moving vision, and go but a very little faster than light itself, we shall overtake successively the visual images of all successive events, and see them as truly as a distant spectator (and what spectator is not more or less distant?) sees what passes before his eyes. We might thus see now what is passing around us, and the next minute, by rushing to the borders of the solar system, where the images are still travelling outwards, see the first inhabitant of this island placing his foot upon its coast; and in the intermediate distances we should successively overtake and see, with our bodily eyes, in inverted order, the events of the English, Norman, Saxon, Roman, and British times; and we might mark, at each period, the food, the clothing, the arms, the tools, the houses, the machines, and the ornaments of the various times.

Now that which this scientific dream thus presents to us in imagination, the Exhibition of the Industry and Arts of all Nations has presented as a visible reality; for we have had there collected examples of the food and clothing and other works of art of nations in every stage of the progress of art. From Otaheite, so long in the eyes of Englishmen the type of gentle but uncultured life, Queen Pomare sends mats and cloth, head-dresses and female gear, which the native art of her women fabricates from their indigenous plants. From Labuan, the last specimen of savage life with which this country has become connected, we have also clothes and armour, weapons and musical instruments. From all the wide domains which lie within or around our Indian empire we have rich and various contributions; from Sincapore and Ceylon, Celebes and Java, Mengatal and Palembang. The ruder and more primitive of these regions send us their native food and clothing, their fishing nets and baskets; but art soon goes beyond these first essays. From Sumatra we have the loom and the plough, lacquered work and silken wares; and as we proceed from these outside regions to that central and ancient India, so long the field of a peculiar form of civilization, we have endless and innumerable treasures of skill and ingenuity, of magnificence and beauty. And yet we perceive that, in advancing from these to the productions of our own form of civilization, which has, even in that country, shewn its greater power, we advance also to a more skilful, powerful, comprehensive, and progressive form of art. And looking at the whole of this spectacle of the arts of life in all their successive stages, there is one train of reflection which cannot fail I think to strike us; namely, this:—In the first place, that man is, by nature and universally, an artificer, an artisan, an artist. We call the nations, from which such specimens came as those which I first mentioned, rude and savage, and yet how much is there of ingenuity, of invention, of practical knowledge of the properties of branch and leaf, of vegetable texture and fibre, in the works of the rudest tribes! How much, again, of manual dexterity, acquired by long and persevering practice, and even so, not easy! And then, again, not only how well adapted are these works of art to the mere needs of life, but how much of neatness, of prettiness, even of beauty, do they often possess, even when the work of savage hands! So that man is naturally, as I have said, not only an artificer, but an artist. Even we, while we look down from our lofty summit of civilized and mechanically-aided skill upon the infancy of art, may often learn from them lessons of taste. So wonderfully and effectually has Providence planted in man the impulse which urges him on to his destination,—his destination, which is, to mould the bounty of nature into such forms as utility demands, and to shew at every step that with mere utility he cannot be content. And when we come to the higher stages of cultured art—to the works of nations long civilized, though inferior to ourselves, it may be, in progressive civilization and mechanical power, how much do we find in their works which we must admire, which we might envy, which, indeed, might drive us to despair! Even still, the tissues and ornamental works of Persia and of India have beauties which we, with all our appliances and means, cannot surpass. The gorgeous East showers its barbaric pearl and gold into its magnificent textures. But is there really anything *barbaric* in the skill and taste which they display? Does the Oriental prince or monarch, even if he confine his magnificence to native manufactures, present himself to the eyes of his slaves in a less splendid or less elegant attire than the nobles and the sovereigns of this our Western world, more highly civilized as we nevertheless deem it? Few persons I think would answer in the affirmative. The silks and shawls, the embroidery and jewellery, the moulding and carving, which those countries can produce, and which decorate their palaces and their dwellers in palaces, are even now such as we cannot excel. *Oriental* magnificence is still a proverbial mode of describing a degree of splendour and artistical richness which is not found among ourselves.

What, then, shall we say of ourselves? Wherein is our superiority? In what do we see the effect, the realization, of that more advanced stage of art which we conceive ourselves to have attained? What advantage do we derive from the immense accumulated resources of skill and capital—of mechanical ingenuity and mechanical power—which we possess? Surely our imagined superiority is not all imaginary; surely we really are more advanced than they, and this term "advanced" has a meaning; surely that mighty thought of a PROGRESS in the life of nations is not an empty dream; and surely our progress has carried us beyond them. Where, then, is the import of the idea in this case? What is the leading and characteristic difference between them and us, as to this matter? What is the broad and predominant distinction between the arts of nations rich, but in a condition of nearly stationary civilization, like Oriental nations, and nations which have felt the full influence of progress like ourselves?

If I am not mistaken, the difference may be briefly expressed thus:—That in those countries the arts are mainly exercised to gratify the tastes of the few; with us, to supply the wants of the many. There, the wealth of a province is absorbed in the dress of a mighty warrior; here, the gigantic weapons of the peaceful potentate are used to provide clothing for the world. For that which makes it suitable that machinery, constructed on a vast scale, and embodying enormous capital, should be used in manufacture, is that the wares produced should be very great in quantity, so that the smallest advantage in the power of working, being multiplied a million fold, shall turn the scale of profit. And thus such machinery is applied when wares are manufactured for a vast population;—when millions upon millions have to be clothed, or fed, or ornamented, or pleased, with the things so produced. I have heard one say, who had extensively and carefully studied the manufacturing establishments of this country, that when he began his survey he expected to find the most subtle and refined machinery applied to the most delicate and beautiful kind of work—to gold and silver, jewels and embroidery; but that when he came to examine, he found that these works were mainly executed by hand, and that the most exquisite and the most expensive machinery was brought into play where operations on the most common materials were to be performed, because these were to be executed on the widest scale. And this is when coarse and ordinary wares are manufactured for the many. This, therefore, is the meaning of the vast and astonishing prevalence of machine-work in this country:—that the machine with its million fingers works for millions of purchasers, while in remote countries, where magnificence and savagery stand side by side, tens of thousands work for one. There Art labours for the rich alone; here she works for the poor no less. There the multitude produce only to give splendour and grace to the despot or the warrior whose slaves they are, and whom they enrich; here the man who is powerful in the weapons of peace, capital and machinery, uses them to give comfort and enjoyment to the public, whose servant he is, and thus becomes rich while he enriches others with his goods. If this be truly the relation between the condition of the arts of life in this country and in those of others, may we not with reason and with gratitude say, that we have indeed reached a point beyond theirs in the social progress of nations?

I have, perhaps, detained you too long with these general reflections, suggested by the mere general aspect of that great display of the works of nations in every stage of progress, which we have had lately before our eyes. But I hope you will recollect, that I began by claiming the privilege of speaking as a mere spectator, who had not had occasion to study the objects there assembled in a special and official manner. There is, however, one view of the subject, perhaps, a little less obvious, which I should wish to endeavour to bring before you: I mean, the view suggested by the *Classification* of which such a collection has been found to be capable. Perhaps, at the first thought it might be supposed that to divide any collection of things, however numerous and various, into classes, is a work of no great difficulty, though when the collection is great, it may require much time. For it might be said, You have only to determine according to what resemblances and what differences you will make your classes, and then to go through the work, sticking to these. But any one who has attended a little more to the science of classification, or even who has made the attempt on any considerable scale, knows that this is not so; and that, except the scheme of classes be very skilfully and very happily devised, it lands us in intolerable incongruities, and even in impossibilities. Indeed, without seeking any exemplification of this remark in the classificatory sciences, which can throw on this subject only a distant and doubtful light, we have experimental evidence of the difficulty of classifying a great collection of the products of art and industry, in the attempts which were made to perform that task on the occasions of the French *Expositions* in 1806, in 1819, in 1827, in 1834, and in 1844. On the first occasion, the distribution adopted was entirely geographical; on the second, it was what was called an entirely material or natural system, dividing the arts into thirty-nine heads, the consequence of which is said to have been great confusion. In 1827 a purely scientific arrangement was attempted, into five great divisions, namely, *chemical, mechanical, physical, economical,* and *miscellaneous arts.* But this was deemed too artificial and abstract, and in 1834 M. Dupin made the division depend on the relation of the arts to man, as being *alimentary, sanitary, vestiary, domiciliary, locomotive, sensitive, intellectual, preparative, social.* This analysis was also adhered to in 1839. In 1844 an attempt was made to unite some features of the previous systems, and the objects were classified as *woven, mineral, mechanical, mathematical, chemical, fine arts, ceramic,* and *miscellaneous;* which was still complained of as confused, but which was, on the whole, retained in 1849.

I do not think there is any presumption in claiming for the classification which has been adopted in the Great Exhibition of 1851 a more satisfactory character than we can allow to any of those just mentioned, if we ground our opinion either upon the way in which this last classification was constructed, or upon the manner in which it has been found to work. And there is one leading feature in it which, simple as it may seem, at once gives it a new recommendation. In the systems already mentioned there were no *gradations* of classification. There were a certain number, thirty-nine or five, nine or eight, of co-ordinate classes, and that was all. In the arrangement of the Great Exhibition of 1851, by a just and happy thought, a division was adopted of the objects to be exhibited into four great *Sections,* to which other *Classes*, afterwards established, were to be subordinate; these Sections being, *Raw Materials*, *Machinery*, *Manufactured Goods, and the works of the Fine Arts.* The effect of this grand division was highly beneficial, for within each of these sections classes could be formed far more homogeneous than was possible while these sections were all thrown into one mass; when, for instance, the cotton-tree, the loom, and the muslin, stood side by side, as belonging to *vestiary* art; or when woven and dyed goods were far removed, as being examples, the former of *mechanical*, the latter of *chemical* processes. Suitable gradation is the *felicity* of the classifying art, and so it was found to be in this instance.

But within this limit how shall classes be formed? Here, also, it appears to me, simply as a reader of the history of the Exhibition, which any one else may read, that the procedure of those who framed the classification was marked with sound good sense and a wise rejection of mere technical rules. For by assuming fixed and uniform principles of classification we can never obtain any but an artificial system, which will be found, in practice, to separate things naturally related, and to bring together objects quite unconnected with each other. It was determined, that within each of the four sections the divisions which had been determined by commercial experience to be most convenient should be adopted. "Eminent men of science and of manufactures in all branches were invited to assist in drawing each one the boundaries of his own special class of productions."* And it was resolved, for the general purposes of the Exhibition, to adopt thirty broad divisions; of which Classes, four were of Raw Materials; six of Machinery; nineteen of Manufactures; and one of the Fine Arts. And these thirty Classes may be considered as having been confirmed by their practical application to the collection, and to the work of the juries in dealing with it; except that, in some instances, it was found necessary to subdivide a Class into others. Thus, Class X., which was originally described as Philosophical Instruments, was found to consist of materials so heterogeneous, that there were separated from it three Classes, of Musical, of Horological, and of Surgical Instruments. And to Class V., Machines, was added an Accessory Class, V *a*, Carriages. And, on the other hand, Classes XII. and XV., Woollen and Worsted, it was found could be advantageously thrown into one.

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* "Illustrated Catalogue," Introd., p. 22.

Within these Classes, again, were other subdivisions, which are marked in the Catalogue by letters of the alphabet. Thus, the Third Class consists of *substances used for food;* and of these the vegetable division contains *Sub-classes*, A, B, C, D, E, F, G: the *first* being *cereals*, and the like; the *second*, *fruits;* the *third*, *drinks*, and so on. And in like manner, the Sixth Class, *manufacturing machines and tools*, had Sub-classes, A, B, C, D, E, F: as A, all *spun and woven fabrics;* B, *manufactures of metals;* C, *manufactures of minerals and mining machinery*, and the like.

And, again, each of these Sub-classes was separated into Heads, by numbers. Thus, the Sub-class *cereals* and the like, are 1, the *common cereals;* 2, the *less common;* 3, *millet;* 4, *pulse and cattle-food;* 5, *grasses and roots;* 6, *flours* (ground grain); 7, *oil seeds;* 8, *hops.* And the Sub-class A, of *manufacturing machines and tools*, included the Heads, 1, *machinery for spinning and weaving cotton, wool, flax, hemp, silk,—for working caoutchouc, gutta percha, hair;* 2, *paper-making;* 3, *printing.* And to shew how much practical experience governed these sub-divisions, I may mention that great aid in this task was found in the Trades' Directories of Birmingham and Manchester, and other great manufacturing towns.

I have followed this classification into the ultimate ramification of the Catalogue, at the risk of being, I fear, tedious for a moment; partly because I wish to make a reflection upon it; and partly, also, that you may see what a vast work is performed if this classification be really coherent and sound. For, first, turn your attention to the one Head which I have mentioned: this single Head includes no less than this,—all machinery for the complete formation, from the raw material, of all fabrics of cotton, wool, flax, hemp, silk, caoutchouc, gutta percha, and hair. This is Head 1 of Sub-class A. Under this Head, or under the first Particular Head, *cotton*, are very many *Articles* in the Great Exhibition. Besides this Particular Head, and the other Particular Heads, *wool, flax, caoutchouc, &c.*, included in the General Head 1, there are two other Heads in this Sub-class, each of like extent. Along with this Sub-class A, are also Sub-classes B, C, D, E, F, each of an extent not much inferior to A; and thus, this Class VI. contains a great mass of Heads, each including a vast number of Articles. Yet in the Catalogue, this Class VI. is one of the smallest extent of all the thirty. And though this may arise in part from some of the others being followed out into greater comparative detail than this Class VI., yet still enough will remain in this mode of putting the matter to shew to you how vast and varied is the mass of objects which has thus been classified, and how great the achievement is if this mass have really been reduced into permanent order; if this chaos, not of elements only, but of raw materials mixed with complicated machines, with manufactured goods and sculptured forms, have really been put in a shape in which it will permanently retain traces of the ordering hand.

What the value and advantage would be of a permanent and generally accepted classification of all the materials, instruments, and productions of human art and industry, you will none of you require that I should explain at length. One consequence would be that the manufacturer, the man of science, the artisan, the merchant, would have a settled common language, in which they could speak of the objects about which they are concerned. It is needless to point out how much this would facilitate and promote their working together; how fatal to co-operation is diversity and ambiguity in the language used. One of our old verse writers, expanding according to the suggestions of his fancy, the account of the failure of men in the case of the tower of Babel, has made this cause of failure very prominent. He supposes that, the language of the workmen being confounded, when one of them asked for a spade, his companion brought him a bucket; or when he called for mortar, handed him a plumb-line; and that, by the constant recurrence of these incongruous proceedings, the work necessarily came to a stand. Now the conditions necessary, in order that workmen may work together, really go much farther than the use of a common language, in the general sense of the phrase. It is not only necessary that they should call a brick a brick, and a wire a wire, and a nail a nail, and a tube a tube, and a wheel a wheel; but it is desirable, also, that wires, and nails, and tubes, and wheels, should each be classified and named, so that all bricks should be of one size, so that a wire number 3, or a tube section 1, or a six-inch wheel, should have a fixed and definite signification; and that wires, and tubes, and wheels, should be constructed so as to correspond to such significations; and even, except for special purposes, no others than such. It may easily be conceived, for instance, how immensely the construction, adjustment, and repair of wheel-work would be facilitated, if wheels of a certain kind were all made with teeth of the same kind, so that any one could work in any other. And something of this sort,—something which secures some of these and the like advantages, has been done with reference to cast-iron toothed wheels. And an eminent engineer, whose works stood in the Sixth Class of the collection to which I have just referred, has proposed a system by which a like uniformity should be secured in the dimensions and fitting of machinery; and especially with regard to screws; fixing thus their exact diameter and pitch, as it is called—a process which would have the like effect of making the construction, application, and repair of all work into which screws enter vastly more easy and expeditious than it now is. Now these are the great and beneficial effects which follow from a good and generally accepted sub-classification of one of the lowest members of that classification which the Catalogue exhibits to us. Mr Whitworth would classify screws, and wheels, and axles, as the millwrights have classified toothed wheels. But screws, or wheels, or axles, are merely one kind of tool, one element of machinery; and tools and machinery are only one class out of thirty of the great collection of which we are speaking. If, then, so great benefits arise from a common understanding as to the species of one of the lowest members of our classification, may we not expect corresponding advantages from a fixation of the names and distinctions of the higher members?—of the names of tools and machines, for instance; and from a perception of their relations to each other, which a good classification brings into view; and then, again, from a clear perception of the relation of class to class and of their lines of demarkation? And may we not expect that on such grounds, the very language of Art and Industry, and the mode of regarding the relations of their products, shall bear for ever the impress of the Great Exhibition of 1851?

There is one other remark which I should wish to make, suggested by the classification of the objects of the Exhibition; or, rather, a remark which it is possible to express, only because we have such a classification before us. It is an important character of a right classification, that it makes general propositions possible; a maxim which we may safely regard as well grounded, since it has been delivered independently by two persons, no less different from one another than Cuvier and Jeremy Bentham. Now, in accordance with this maxim, I would remark, that there are general reflections appropriate to several of the divisions into which the Exhibition is by its classification distributed. For example, let us compare the First Class, *Mining and Mineral Products,* with the Second Class, *Chemical Processes and Products.* In looking at these two classes, we may see some remarkable contrasts between them. The first class of arts, those which are employed in obtaining and working the metals, are among the most ancient; the second, the arts of manufacturing chemical products on a large scale, are among the most modern which exist. In the former class, as I have said, Art existed before Science; men could shape, and melt, and purify, and combine the metals for their practical purposes, before they knew anything of the chemistry of metals; before they knew that to purify them was to expel oxygen or sulphur; that combination may be definite or indefinite. Tubal-Cain, in the first ages of the world, was "the instructor of every artificer in brass and iron;" but it was very long before there came an instructor to teach what was the philosophical import of the artificer's practice. In this case, as I have already said, Art preceded Science; if even now Science has overtaken Art; if even now Science can tell us why the Swedish steel is still unmatched, or to what peculiar composition the Toledo blade owes its fine temper, which allows it to coil itself up in its sheath when its rigid thrust is not needed. Here Art has preceded Science, and Science has barely overtaken Art. But in the second class, Science has not only overtaken Art, but is the whole foundation, the entire creator of the art. Here Art is the daughter of Science. The great chemical manufactories which have sprung up at Liverpool, at Newcastle, at Glasgow, owe their existence entirely to a profound and scientific knowledge of chemistry. These arts never could have existed if there had not been a science of chemistry; and that, an exact and philosophical science. These manufactories now are on a scale at least equal to the largest establishments which exist among the successors of Tubal-Cain. They occupy spaces not smaller than that great building in which the productions of all the arts of all the world were gathered, and where we so often wandered till our feet were weary. They employ, some of them, five or six large steam-engines; they shoot up the obelisks which convey away their smoke and fumes to the height of the highest steeples in the world; they occupy a population equal to that of a town, whose streets gather round the walls of the mighty workshop.* Yet these processes are all derived from the chemical theories of the last and the present century; from the investigations carried on in the laboratories of Scheele and Kirwan, Berthollet and Lavoisier. So rapidly in this case has the tree of Art blossomed from the root of Science; upon so gigantic a scale have the truths of Science been embodied in the domain of Art.

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* "Illustrated Catalogue," p. 184.

Again, there is another remark which we may make in comparing the First Class, *Minerals*, with the Third Class, or rather with the Fourth, *Vegetable and Animal Substances used in manufactures, or as implements or ornaments.* And I wish to speak especially of *vegetable* substances. In the class of *Minerals*, all the great members of the class are still what they were in ancient times. No doubt a number of new metals and mineral substances have been discovered; and these have their use; and of these the Exhibition presented fine examples. But still, their use is upon a small scale. Gold and iron, at the present day, as in ancient times, are the rulers of the world; and the great events in the world of mineral art are not the discovery of new substances, but of new and rich localities of old ones,—the opening of the treasures of the earth in Mexico and Peru in the sixteenth century, in California and Australia in our own day. But in the vegetable world the case is different; there, we have not only a constant accumulation and reproduction, but also a constantly growing variety of objects, fitted to the needs and uses of man. Tea, coffee, tobacco, sugar, cotton, have made man's life, and the arts which sustain it, very different from what they were in ancient times. And no one, I think, can have looked at the vegetable treasures of the Crystal Palace without seeing that the various wealth of the vegetable world is far from yet exhausted. The Liverpool Local Committee have enabled us to take a starting-point for such a survey, by sending to the Exhibition a noble collection of specimens of every kind of import of that great emporium; among which, as might be expected, the varieties of vegetable produce are the most numerous. But that objects should be reckoned among *imports*, implies that already they are extensively used. If we look at the multiplied collections of objects of the same kind, some from various countries, not as wares to a known market, but as specimens and suggestions of unexplored wealth, we can have no doubt that the list of imports will hereafter, with great advantage be enlarged. Who knows what beautiful materials for the makers of furniture are to be found in the collections of woods from the various forests of the Indian Archipelago, or of Australia, or of Tasmania, or of New Zealand? Who knows what we may hereafter discover to have been collected of fruits and oils, and medicines and dyes; of threads and cordage, as we *had* here from New Zealand and from China examples of such novelties; of gums and vegetable substances, which may, in some unforeseen manner, promote and facilitate the processes of art? How recent is the application of caoutchouc to general purposes! Yet we know now—and on this occasion America would have taught us if we had not known—that there is scarcely any use to which it may not be applied with advantage. If a teacher in our time were to construct maxims like those of the son of Sirach in the ancient Jewish times—like him who says (Ecclus. xxxix., 26) "The principal things for the whole use of man's life are water, fire, iron, and salt, flour of wheat, honey, milk, and the blood of the grape, oil, and clothing"—he could hardly fail to make additions to the list, and these would be from the vegetable world. Again, how recent is the discovery of the uses of gutta percha! In the great collection were some of the original specimens sent by Dr Montgomery to the India House, whence specimens were distributed to various experimentalists.* Yet how various and peculiar are now its uses, such as no other substance could replace! And is it not to be expected that our contemporaries, joining the insight of science to the instinct of art, shall discover, among the various sources of vegetable wealth which the Great Exhibition has disclosed to them, substances as peculiar and precious, in the manner of their utility, as those aids thus recently obtained for the uses of life?

And before we quit this subject, let us reflect, as it is impossible, I think, not to reflect, when viewing thus the constantly enlarging sphere of the utility which man draws from the vegetable world, what a view this also gives us of the bounty of Providence to man, thus bringing out of the earth, in every varying clime, endless forms of vegetable life, of which so many, and so many more than we yet can tell, are adapted to sustain, to cheer, to benefit, to delight man, in ways ever kind, ever large, ever new, and of which the novelty itself is a new source of delighted contemplation.

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* "Illustrated Catalogue," p. 876.

I might go on to make other reflections upon the peculiar characters of the various classes of the Great Exhibition, but the time does not allow me, nor is it needful, since all that I aspired to do was to offer to you specimens of such reflections. Several of the classes will, no doubt, suggest appropriate reflections to those who have to deliver lectures to you on special subjects. In the meantime, though I must now hasten to a conclusion, I cannot but perceive how imperfectly I have discharged even the limited task which I ventured to undertake. For I have as yet said nothing of the effect which must be produced upon art and science by this gathering of so many of the artists and *scientists* (if I may use the word) of the world together; by their joint study of the productions of art from every land, by their endeavours to appreciate and estimate the merits of productions, and instruments of production; of works of thought, skill, and beauty.

In speculating concerning universities, we are accustomed to think that, without underrating the effect of lectures and tasks, of professors and teachers, still that among the most precious results of such institutions is the effect produced upon those who resort thither by their intercourse with, and influence upon, each other. We know that by such intercourse there is generated a community of view, a mutual respect, and a general sympathy, with regard to the elements of a liberal education, and the business of national, social, and individual life, which clings to men ever after, and tends to raise all to the level of the best. And some such effect as this would, we may suppose, be produced upon the students of the useful and the beautiful arts by their resort to any university in common. To *any* university, I have said; but to what a university have they been resorting during the past term? To a University of which the Colleges are all the great workshops and workyards, the schools and societies of arts, manufactures, and commerce, of mining and building, of inventing and executing in every land—Colleges in which great chemists, great mechanics, great naturalists, great inventors, are already working, in a professional manner, to aid and develope all that capital, skill, and enterprise can do. Coming from such Colleges to the central University, may we not well look upon it as a great epoch in the life of the Material Arts, that they have thus begun their university career—that they have had the advantage of such academical arrangements as there have been found, and still more, as I have said, that they have had the greater advantage of intercourse with each other? May we not expect that from this time the eminent producers and manufacturers, artizans and artists, in every department of art, and in every land, will entertain for each other an increased share of regard and good-will, of sympathy in the great objects which man's office as producer and manufacturer, artizan and artist, places before him—of respect for each other's characters, and for the common opinion of their body, all increased by their being able to say, "We were students together at the Great University in 1851."

On the Infusoria and other Microscopic Forms in Dust-showers and Blood-rain. By Dr C. G. Ehrenberg.

The infusorial character of the dust occasionally transported by winds, is one of the most interesting of Ehrenberg's discoveries. His investigations have been reported from time to time in the Berlin Memoirs and elsewhere, and notices of some of his results have appeared in this journal. A memoir in the Memoirs of the Berlin Academy contains the details of his various researches, with full pictorial illustrations.* The plates contain, not only figures of all the forms observed in each case, but a sketch of a portion of the dust as it lay under the field of his microscope, exhibiting to the eye the relative prevalence of different forms, and the colours they presented. The showers, whose microscopic organisms are here reported, are as follows:—

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* *Vide* Passatstaub und Staubregen. Grosses organisches unsichtbares Wirken und Leben in der Atmosphäre. Von Hrn. Ehrenberg. Abhandlungen der Academie der Wissenschaften zu Berlin, 1847.

I. *In the Atlantic, latitude* 17° 43′ *N., and longitude* 26° *W., about* 500 *miles from the coast of Africa.*—The dust was collected by Mr Darwin, from the ship in which he was at the time. The direction of the wind was from the African coast. The dust resembled volcanic ashes, although evidently not of this origin, and about a sixth part of it was silicious shells of fresh water and land infusoria, and silicious phytolites,—eighteen species of the former, and as many of the latter. The most of the forms are European, and none exclusively *African*. Among them there is the South American species *Himantidium papilio*, which occurs at Cayenne, and also a *Surirella*, probably from the same continent. The conclusion follows, as Ehrenberg observes, that either the dust came in part from South America, in the upper regions of the atmosphere, or these two species are yet to be discovered elsewhere.

II. *Other Dust-showers in the Atlantic, from the Collections of Mr Darwin.*—These collections were made between the years 1834 and 1838, in latitudes 15°, 17°, 19°, and 21°, part at San Jago (Cape Verds), and part within 250 miles of the land, in the open sea, between longitudes 22° and 26°. They afford thirty new forms to those of the shower above noticed, and include also the same South American forms, *Himantidium papilio*, and *Surirella Peruviana.* In addition, there are three species of Eunotia, which have been found only in Senegambia and Guiana, together with the *Amphidiscus obtusus*, also South American. Besides the others, there was one Polythalamium, making in all 67 organic forms. The only new species was the *Eunotia longicornis*, which is very similar to a Hungarian fossil species. No species peculiarly African was found in the dust. One, the *Lithostylidium Rajula*, occurs at the Isle of France.

III. *Dust which fell at Malta*, 15*th of May* 1830.—This dust was obtained by Mr Darwin from purser R. G. Didham, of the ship Revenge. The wind at the time was east-south-east, and a similar fall of dust took place at the time, in the bay of Palmas, in Sardinia. The number of species afforded was 43, of which 15 were Infusorial, 21 Phytolitharia, and 7 Polythalamia. Some of the species occur in Africa, yet there are no characteristic African forms—and although such showers, with the hot winds that attend them, are usually referred to the Sahara desert, they appear to be quite foreign to that region. Among the species, *Synedra entomon* is a characteristic form from Chili. In general character, the species are like those of the Cape Verd and other showers.

IV. *Sirocco dust of Genoa, May* 16, 1846.—In this dust, Ehrenberg found 22 species of Polygastrica, 21 of Phytolitharia, and 3 of parts of plants. The forms have much resemblance to those of the Malta and Atlantic showers. The colour is yellowish or ochreous, from oxide of iron, and not grey like the true African dust, and about one-sixth to one-third of the mass is organic. None of the species are characteristic African forms, and *Synedra entomon* is South American.

It follows from the preceding results that the showers of the Atlantic, of Malta and of Genoa, are in general alike, in organic, as well as inorganic constitution, *and in the absence of characteristic African forms;* and this resemblance is the more surprising, as the observations extend through the long period of 16 years, from 1830 to 1846. They are alike, also, in the brownish red colour of the dust.

V. *Sirocco dust of Lyons, Oct.* 17, 1846.—The Lyons shower afforded 39 species of Polygastrica, 25 of Phytolitharia, 3 of Polythalamia, besides minute portions of plants. In this shower, the organic forms make up about one-eighth of the mass. In general character, including colour, there is a close resemblance to the products of the Atlantic showers and the others above described. The species are nearly all of fresh-water or land origin; one-seventh only are marine species. The most abundant forms of Polygastrica are Eunotia amphioxys, E. gibberula, E. longicornis, *Gallionella decussata*, *G. granulata*, and *G. procera;* and those of *Phytolitharia*, *Lithostylidium Amphiodon*, *L. ossiculum*, and *L. rude.*

There are two South American species, the *Eunotia Pileus* and *Himantidium Zygodon.*

The number of species brought to light from the dust of nine showers thus far described, is as follows:—

Polygastrica, 57; Phytolitharia, 46; Polythalmia, 8.

Besides these, there are seven kinds of particles from plants, and are fragments from an insect. Seventeen of the species are marine, and the other 102 of fresh-water origin. There is no evidence of volcanic origin.

VI. *Second specimen from the Genoa shower of the* 16*th of May* 1846.—All but one of the forms mentioned were observed in the former specimen of the dust.

VII. *Storm of red snow in Puster Valley, in Tyrol, March* 31, 1847.—This red snow owed its colour to a coloured dust, much resembling that of the Atlantic. Its tint is brownish red.

It afforded, as obtained at two localities, 66 organic forms, 22 of which were Polygastrica, 28 Phytolitharia, 2 Polythalamia, 13 particles of plants, and 1 of an insect. The large majority of the species are known fresh water and continental forms; only 4 to 6 species are unknown, 2 are marine, namely, *Coscinodiscus radiolatus*, and a Spiroloculina (?). There is a remarkable resemblance in the colour and character of the dust to that of the Atlantic, Genoa, and Lyons, and an identity in many of the species; 46 species out of the 66 occur in the Sirocco and Atlantic dust; 12 Polygastric species, and 20 Phytolitharia are common to the Atlantic showers and the Tyrolese snows. This uniformity of character over regions so widely separate, yet in nearly a common latitude or zone, and in so many distinct examples through a number of years is most surprising.

VIII. *Dust which fell in Italy in* 1803, *and in Calabria in* 1813.—The former of these showers is represented as coming from the south-east. It afforded 49 species, and that of Calabria 64. Out of the 49, 39 have been observed in the more recent showers; and out of the 64, 51 are like the more recent. These showers, although ten years apart, have 23 species in common, or about one-fourth. In both nearly all the species are of fresh water or continental origin. In both, as in other showers, the most abundant species are Eunotia amphioxys, *Gallionella granulata*, *G. crenata*, *G. distans*, *G. procera*, *Lithodontia*, *Lithostylidia*. In both, also, there are four South American forms; *Coscinodiscus flavicans* from Peru and St Domingo; *Navicula undosa* from Surinam; Stauroneis *linearis* from Chili and North America; *Synedra Entomon* from Chili. The last occurs also in Africa and Asia. There are no characteristic African species.

Ehrenberg next mentions facts of a similar kind of earlier date. Humboldt when in Paramo, on the way from Bogota to Popayan, at a height of 2300 toises (14,700 feet), observed a red hail, a fact published by him in the Annales de Chemie for 1825. The height of the place gives peculiar interest to the observation.

In 1755, on the 14th of October, at 8 o'clock in the morning, a warm Sirocco wind was blowing at Locarno, near Lago Maggiora. At 10 o'clock the air was filled with a red mist, and at 4 o'clock, P.M. there was a blood-red rain, which left a reddish deposit, equal to one-ninth of its mass. There fell 9 inches of this rain in one night. About 40 square German leagues were covered with this bloody rain, which also extended on the north side of the Alps into Suabia, and 9 feet of reddish snow fell upon the Alps. Supposing that the deposit averaged but two lines in depth, there would be for each square English mile an amount equal to 2700 cubic feet. But actual measurement gave for the depth in some places about one inch (or ⅛th of 9 inches).

In 1623 there was another blood-rain at Strasburg. It happened on the 12th August, between the hours of four and five in the afternoon. In the year 1222 a similar rain fell at Rome for one day and night. Many other like facts are cited.

Ehrenberg favours the view of the atmospheric origin of these showers, and speaks of their relation to the fall of aerolites. Chladni, in his work on Meteorites, observes that the stones which fell between 1790 and 1819, amounted to not less than 600 cwt.; while for the single dust-shower of Lyons in 1846, the material that fell was full 7200 cwt. The Cape Verd shower had a breadth, according to Darwin,* of more than 1600 miles, and according to Tuckey, of 1800 miles, and extended 600 to 800 miles, or even 1000 miles from the African coast. This gives an area of 960,000 to 1,280,000, or from 1,648,000 to 1,854,000 square miles.

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* Quarterly Jour. Geol. Soc., No. 5, 1846, p. 26.

The surface of Italy is about 90,000 square miles; that of Sicily 10,000 square miles, making together 100,000. A single dust-shower, covering both countries like that of 1803, to the extent of that of Lyons in 1846, would deposit 112,800 cwt. of dust in a single day. With such facts before us, Ehrenberg asks, how many thousand millions of hundred-weight of microscopic organisms have reached the earth since the period of Homer, the time of our earliest record of such events? He adds, "I cannot longer doubt, that there are relations according to which living organisms may develope themselves in the atmosphere;" and he speaks of this as a self-development and not a production from introduced ova. He supposes it probable that the atmospheric dust-cloud region is of vast extent, and is above a height of 14,000 feet. The facts may seem inexplicable on any other hypothesis; yet much more investigation will be required before an opinion so contrary to received principles can be generally adopted.

Showers of Blood.

The work proceeds with a historical relation of all showers of dust, blood-rain, red snow, and similar phenomena, from the earliest records to the present time. This history occupies 100 pages of the volume.

The *first* instance adduced dates about 1500 years before the present era. It is the plague of blood inflicted upon the Egyptians, as related in the Mosaic history, which prevailed throughout the whole land of Egypt, continuing three days and three nights.

The *second* occurred about 1181 B.C., the time of Æneas and Dido, as related by Virgil, Æneid iv., 454:—

> "Horrendum dictu, latices nigrescere sacros.
> Visaque in obscœnum se vetere vina cruorem."

The *third*, about 950 B.C., as described by Homer, Ilias xi., v. 52, 54, and also Ilias xvi., v. 459, 460.

The *fourth*, about 910 B.C., is the instance of bloody waters mentioned in connection with the victory over the Moabites in 2 Kings iii., v. 21, 22, 23.

Ehrenberg mentions then the rain of blood in the time of

Romulus, as related by Livy, and goes on with other accounts of subsequent date, with regard to which the information is not of as doubtful character as with those just alluded to.

A supplemental chapter contains a notice of meteoric dust showers since 1846. One on the 31st March 1847, in the valley of Gastein, in Salzburg; another in Arabia, January 24, 1848; another in Silesia and Lower Austria, January 31, 1848. The showers afforded similar fresh water and continental forms, with the same South American species before-mentioned, and no characteristic African form. Other showers occurred in 1849. In March there was a reddish dust fell at Catania in Sicily, during a south wind. On the 14th April, during a hail storm in Ireland, there was a black inky deposit, affording numerous microscopic organisms.

The number of showers which Ehrenberg records is in all 340, 81 before Christ and 249 after Christ. Ehrenberg remarks that these showers appear to prevail most within a zone extending from the part of the Atlantic off the west coast of Middle and North Africa, along in the direction of the Mediterranean Sea, reaching a short distance north of this sea, and continued into Asia between the Caspian Sea and the Persian Gulf, perhaps to Turkistan, Kaschgar, and China; and they seldom reach north to Sweden and Russia. This zone, according to the observations of Tuckey, has a breadth of 1800 miles in the north torrid zone. The reddish colour of the dust, as well as the organic forms, shew that the dust is not of African origin. Moreover, the storm winds and sirocco are found to afford the same species of organisms.

Ehrenberg repeats again his opinion that these phenomena are not to be traced to mineral materials from the earth's surface, nor to revolving masses of dust material in space, nor to atmospheric currents simply; but to some general law connected with the earth's atmosphere, according to which there is a self-development within it of living organisms.

The whole number of species of organisms observed is 320. 1,2 ,0 e genera there are only the following: Coscinodiscus, Diploneis, Goniothecium, Grammatophora, and Biddulphia, besides some Polythalmia and Spongolites. The following are American forms :—

Arcella constricta,
Desmogonium Guayanense,
Eunotia Camelus,
... depressa,
... Pileus,
Naviculo undosa,
Synedra Entomon,
Eunotia quarternaria,
... quinaria,
Gomphonema Vibrio,
Himantidium Papilio,
... Zygodon,
Stauroneis dilatata,
Guiriella Peruana,
Fragmenta incerta.

A simultaneous occurrence of dust showers and falls of meteoric stones, has been observed in probably eighteen instances before the Christian era. During the Christian era, *fourteen* coincidences have been observed, making thirty-two in all.

(*Tables and Drawings of Infusoria in a future Number.*)

Singing Birds and Sweet Flowers in Jamaica.

"In tropical countries, where brilliant and varied colours have been granted to the birds and flowers, song has been denied to the one and fragrance to the other." This is one of those flippant generalisations which people are fond of repeating, originally made without investigation, and perpetuated without inquiry. In Jamaica it is certainly very far from truth; and I suspect would be found as groundless everywhere else. The groves and fields of this sunny isle ring with the melody of birds, to a degree fully equal, in my judgment, to that of Europe. In the lone forests of the mountain heights the Glass-eye Merle (*Merula Jamaicensis*) pours forth a rich and continued song; and that mysterious harmonist, the Solitaire (*Ptilogonys armillatus*), utters his sweet but solemn thrills, long-drawn and slow, like broken notes of a psalm, so perfectly in keeping with the deep solitude. In the woods that cover, as with an ever verdant crown, the lower hills, the Black Shrike (*Tityra leuconotus*), and the Cotton-tree Sparrow (*Pyrrhula violacea*), enunciate their clear musical calls, so much alike as scarcely to be distinguished; four or five notes running up the scale so rapidly, as to be fused as it were together, and suddenly falling at the end. There, too, sits the Hopping Dick (Merula leuco*genys*), and whistles, by the hour together, a rich and mellow succession of wild notes, clear and flute-like, like his European cousin, the Blackbird. The constantly reiterated call of the Red-eyed Flycatcher (*Vireosylva olivacea*), " John to whip! John to whip!" heard at different distances from all parts of the woods, makes their green glades lively; and the loud varied voice of the White-eyed Flycatcher *Vireo Noveboracensis*), sometimes soft and subdued, sometimes shrill and piercing, is always heard with pleasure.

But birds are particularly social animals: and it is chiefly in the neighbourhood of the presence of man that their melodious voices are heard, as if to cheer him in his toil; the fields, and pastures, and meadows, the hedges, and hedgerow trees, that border and map out his domains; the orchards and groves that surround and embosom his dwellings, affording grateful fruit and shadow from the heat:—these are the situations in every inhabited country that most resound with the voices of feathered songsters. The beautiful park-like estates of the southern slopes of Jamaica, present scenes peculiarly inviting and suitable for the winged orchestra to exercise its vocal talent; and the notes of melodious joy are pouring forth in them from earliest dawn to sunset; aye, long before dawn, and long after the veil of night has been outspread. The swallows (*Hirundo pœciloma*) that shoot along in their arrowy traverses over the plains, now darting across the placid stream, now coursing far up in the thin air, almost lost in the glaring sun-beam, twitter sweetly as they pass, and now and then one and another sitting on the summit of a low tree, commence a stammering song by no means deficient in music. The Blue Martins (*Progne Dominicensis*), too, sit side by side in close rows on the dead frond of some tall palm, or on the roof-ridge of the dwelling house and utter a shrill but not unmelodious chant. From the green tussocks of the Guinea-grass fields comes the singular hollow cry of the Tichicro (*Coturniculus tixicrus*), and now and again he runs to the summit of a stone, or jumps upon a wall, and warbles a sweet low song. The clear whistle of the Banana bird (*Icterus leucopteryx*) like the tones of a clarionet, resound from the fruit trees, among whose deep green foliage his gay hues, rich yellow, white, and black, glance fitfully as he shoots to and fro; and his companions, the little Blue

Quits (*Euphonia Jamaica*), equally devoted admirers of a ripe sour sop or custard-apple, accompany his loud notes with strains of their own, full of soft warbling music. And the most minute of birds, the tiny Vervain Humming bird (*Mellisuga humilis*), not larger than a school-boy's thumb, utters a song so sweet, but of sound so alternated withal, that you wonder who the musician can be, and are ready to think it the voice of an invisible fairy; when presently you see the atom of a performer perched on the very topmost twig of a mango or orange tree, his slender beak open and his spangled throat quivering, as if he would expire his little soul in the effort.—*P. U. Gosse, Jamaica.*

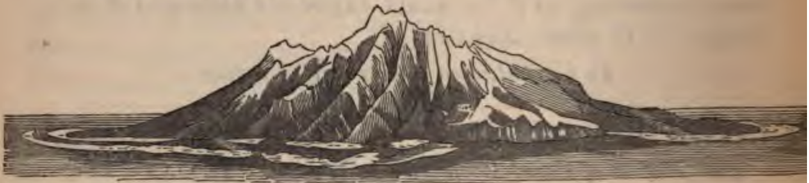
(*To be continued in our next Number.*)

I. *Coral Reefs and Islands.* II. *The Structure, Growth, and Habits of Coral Zoophytes.* By James D. Dana, Esq., Naturalist to the American Exploratory Expedition.

1. *General Features of Coral Reefs and Islands.*

The general features of reefs and coral islands have often been delineated by travellers, and are probably almost as familiar to the reader as the scenes of the land around us. Yet a few brief remarks on this subject will not be out of place here as preliminary to our observations on the structure, growth, and habits of coral zoophytes.

Coral Reefs.—A wide platform of rock covered with the sea, except at low tide, borders most of the high islands of the Pacific. It is a vast accumulation of coral, based upon the bottom in the shallow waters of the shores. This bank or table of coral rock, is of varying width, from a few hundred feet to a mile or more; and, although the surface is usually nearly flat, it is often intersected by irregular boat-channels, or occasionally encloses large bays, affording harbour protection to scores of ships. In very many instances the reef stands at a distance from the shores like an artificial mole, leaving a wide and deep channel between it and the land; and within this channel are other coral reefs, some in scattered patches, and others attached to the shore. The inner reef in these cases, is distinguished as the *fringing reef*, and the outer as the *barrier reef.* The sea rolls in heavy surges against the outer margin of the barrier; but the still waters of a lake prevail within, affording safe navigation for the tottling canoe sometimes through the whole circuit of an island; and not unfrequently, ships may pass, as by an internal canal, from harbour to harbour around the island. The reef is covered by the sea at high tide, yet the smoother waters indicate its extent, and a line of breakers its outline. Occasionally a green island rises from the reef, and in some instances a grove of palms stretches along the barrier for miles, where the action of the sea has raised the coral structure above the waves.



The sketch annexed conveys some idea of the peculiar features presented by a Pacific island, and its encircling reefs, though in order to fill out the scene, the jagged heights and deep gorges of the islands should be covered with forests, and the shores with groves and native villages. The coral platform which borders the shore is represented with its usual uneven line,—its broad harbours with a narrow entrance,—and to the left, an irregular ship-channel running between the inner or fringing reef, and the outer or barrier. At a single place the sea is faced by a cliff, and here, owing to the boldness of the shores and the depth of the waters, the reef is wanting. To the right there is only a fringing reef.

Coral Islands.—Coral islands resemble the reefs just described, except that a lake or lagoon is encircled instead of a mountainous island. A narrow rim of coral reef, generally but a few hundred yards wide, stretches around the enclosed waters.

In some parts it is so low that the waves are still dashing over it into the lagoon; and in others, it is still verdant with the rich foliage of the tropics. The coral-made land, when highest, is seldom elevated over eight or ten feet above high tide.

When first seen from the deck of a vessel, only a series of dark points is descried just above the horizon. Shortly after, the points enlarge into the plumed tops of cocoa-nut trees, and a line of green, interrupted at intervals, is traced along the water's surface. Approaching still nearer, the lake and its belt of verdure are spread out before the eye, and a scene of more interest can scarcely be imagined. The surf beating loud and heavy along the margin of the reef, presents a strange contrast to the prospect beyond,—the white coral beach, the massy foliage of the grove, and the embosomed lake with its tiny islets. The colour of the lagoon water is often as blue as the ocean, although but fifteen or twenty fathoms deep; yet shades of green and yellow are intermingled, where patches of sand or coral knolls are near the surface; and the green is a delicate apple-shade, quite unlike the usual muddy tint of shallow waters.

The belt of verdure, though sometimes continuous around the lagoon, is usually broken in some parts into islets, which are separated by varying intervals of bare reef; and through one or more of these intervals a ship-channel occasionally opens into the lagoon. The larger coral islands are thus a string of islands arranged along a line of coral reef. The King of the Maldives bears the high sounding title of "Ibrahim Sultan, King of the thirteen Atollons and Twelve Thousand Isles;" which Captain W. F. W. Owen, R.N., remarks is no exaggeration.

The usual features of these islands are presented in the above sketch. The narrow belt is seen to consist of several patches of vegetation, and within are the quiet waters which offer a retreat for vessels whenever there is an opening to the lagoon.

A few small coral islands are simple reefs without lagoons. In some cases they are bare banks of coral; but generally, the usual vegetation of the islands has obtained a foothold, and afford some protection against the glare of the coral sand.*

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* For further observations on Coral Reefs and Islands *vide* Dana's Memoir in Silliman's Journal, May 1851.

II. *Structure, Growth, and Habits of Coral Zoophytes.*

1. *Structure and Growth of Zoophytes.*

A singular degree of obscurity has been thrown around the growth of coral zoophytes and coral formations, through the various speculations which have been offered in place of facts; and to the present day, the subject is seldom mentioned without the qualifying adjective *mysterious* expressed or understood. Some writers, scouting the idea that reefs of rocks can be due in any way to "animalcules," talk of electrical forces, the first and the last appeal of ignorance. Others call in the fishes of the seas, suggesting that they are the masons, and work with their teeth in the accumulation of the calcareous material. Very many of those who discourse quite learnedly on zoophytes and reefs, imagine that the polyps are mechanical workers, heaping up these piles of rock by their united labours; and science still retains such terms as polypary, polypidom, as if each coral were the constructed hive or house of a swarm of polyps, like the honeycomb of the bee, or the hillock of a colony of ants.

It is vain to hope to understand fully the works of Him who is himself infinite and incomprehensible. The scrutinizing eye of science penetrates with far-reaching sight the system of things about us, and in the dim limits of vision reads everywhere the word mystery. All life, animal and vegetable, and all that is inanimate, declare it; surely there is no special reason, except such as may arise from want of study and consideration, for attributing it pre-eminently to the humblest grades of existence.

It is not more surprising nor a matter of more difficult comprehension that the polyp should form coral, than that the quadruped should form its bones, or the mollusc its shell. The processes are similar, and so the result; in each case it is a simple animal secretion, a formation of stony matter from the aliment which the animal receives, produced by certain parts of the animal fitted for this secreting process. This power of secretion is the first and most common of those that belong to living tissues; and though differing in different organs according to their end or function, it is all one process, both in nature or cause, whether in the animalcule or in man. Coral is never, therefore, an agglutination of grains made by the handiwork of the many armed polyps; for it is no more an act of labour than bone-making in ourselves. And, again, it is not a collection of cells into which the coral animals may withdraw for concealment, any more than the skeleton of a dog is its house or cell; for every part of the coral of a polyp in most reef-making species is enclosed *within* the polyp where it was formed by the secreting process.*

It is important that this point should be thoroughly understood, and fully appreciated. That error may no longer be perpetuated, the words polypary and the like, have been rejected by the author in his volume on Zoophytes, and the more familiar term corallum has been used instead.† With this introductory explanation we proceed.

a. *Structure of Coral Animals or Polyps.*—A good idea of a coral polyp may be had from comparison with the garden aster; for the likeness in external form and delicacy of colouring is singularly close. The aster consists of a tinted disk bordered with one or more series of petals; and in exact analogy, the polyp flower, in its most common form, has a disk often richly coloured, fringed around with petal-like organs called tentacles. Below the disk, in contrast with the slender pedicel of the plant, there is a stout cylindrical pedicel or body, often as broad as the disk itself, and usually not much longer, which contains the *stomach* and internal cavity of the polyp; and the *mouth*, which opens into the stomach, is placed at the centre of the disk. Here, then, the flower animal and the garden-flower diverge in character, the difference being required by the different modes of nutrition in the two kingdoms of nature.

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* It is not perhaps within the range of science to criticise the poet; yet we may say in this place, in view of the frequent use of the lines even by scientific men, that more error in the same compass could scarcely be found than in the part of Montgomery's Pelican Island, relating to coral formations. The poetry is beautiful, the facts nearly all errors—if literature allows of such an incongruity. For ourselves, we think the poet transcends his appropriate limits, when false to nature.

† See page 15 of the Report on Zoophytes. The term corallium has been set aside by authors because of its being used for a genus of corals. *Corallum* is an old form of the same word, as particularly explained on the page just referred to, and is not liable to this objection. The true nature of calcareous corals was first pointed out by Milne, Edwards, and Ehrenberg.

There are many species of polyps, which have all the external and internal characters of coral polyps, yet secrete no lime or coral. Our descriptions of structure may be best drawn from them, and afterwards the single peculiarity of the coral-making polyp—its secretion of coral—will come under consideration. The species here referred to are called *Actiniæ* in science, in allusion to the radiated or aster-like flower which forms the summit of the animal.* There is the same allusion in the common appellation *Sea Anemone.* The richest anemones, daisies, and tulips of our gardens would not rival them in beauty, neither will they exceed them in the size of their flowers; for a breadth of two and three inches is common. The polyps here alluded to, along with the coral polyps allied, constitute the order or division of zoophytes called Actinoidea.†

The Actiniæ are entirely fleshy, and usually live attached by their lower extremity to the submerged rocks of the shores. The mouth, at the centre of the flower-like disk forming the summit of the animal, is a simple opening without teeth or appendages of any kind. The tentacles—the petals of the flower—are tubular organs, and communicate internally with the interior cavity of the animal. The animal contracts when disturbed, and conceals the flower by rolling inward over it, the margin bearing the tentacles; and in this state it seems like a lifeless lump of animal matter. Left quiet for a while, it again expands and appears as before. This expansion is produced by receiving water into the interior from without, mostly through the mouth, and thus filling the tentacles and swelling out its fleshy body. They are generally found expanded with the mouth wide open to receive their prey. As they are fixed to the rocks, they must wait for their food to come to them. When a crab, shell fish, or any thing alive, within the capabilities of their bodies, comes within reach, they usually secure it by closing upon the victim the tentacles (which commonly have a stinging power), and pushing it into the mouth. In many species the tentacles are too short to aid in capturing food except it be by stinging. These organs subserve also the purpose of aerating the blood, a function in which all parts of the body are more or less concerned.

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* From *αχτιν, a ray of the sun.*

† This term alludes to their general resemblance to Actiniæ.

The interior of the actinia contains a cylindrical stomach suspended from the disk, which opens at bottom into the general cavity of the body. This general cavity, below the stomach and around it, is divided into compartments by radiating fleshy lamellæ, the larger of which in their upper part connect the stomach with the sides of the animal. The most important function of these lamellæ is that of reproduction, some being spermatic, and the others bearing clusters of ova. These ova leave the body by passing out through the stomach and the mouth; but in many instances this does not take place till the young animal has proceeded from them. The refuse from the food after digestion in the stomach is also ejected by the mouth, as this is the only opening to the alimentary cavity. Other excrementitious matters, separated on the final elaboration of the chyle and its assimilation, may escape through the sides of the animal, the openings at the extremities of the tentacles, or in general by whatever pores or passages water may be ejected in the contraction of the animal.

One of the most singular peculiarities of polyps is their ready restoration of a lost part. Even a fragment will go on to complete the entire animal again; as with the fabled hydra of old, the knife is used but to multiply, for every section becomes a new animal.

In all the points mentioned in the description here given, the polyp of ordinary coral and the actinia are identical.

b. *Process of Budding.*—There is one mode of reproduction which, although having no necessary connection with coral secretions, belongs almost exclusively to coral polyps. This is *reproduction by buds*, and the process is so similar to the production of buds in vegetation, that a remembrance of the latter will aid much in conceiving of it. The bud generally commences as a slight prominence on the side of the parent: the prominence enlarges, and soon a circle of tentacles grows out, with a mouth at the centre; enlargement goes on till the young finally equals the parent in size. Thus by budding, a compound group is commenced; and it is evident that if the parent and the new polyp go on budding again and so on, the compound group may continue to enlarge. This is the fact in nature. The polyps, one and all, continue propagating by buds, until in some instances thousands, or hundreds of thousands, have proceeded from a single one, and the colony has spread to a large size. Such is the Madrepora and Astræa. There are modifications of this process analogous to those in vegetation, but we need not dwell upon them in this place.

It is obvious that the connection of the polyps in such a compound group must be of the most intimate kind. The several polyps have separate mouths and tentacles, and separate stomachs; but beyond this there is no individual property. They coalesce, or are one, by intervening tissues, and there is a free circulation of fluids through the many pores or lacunes. The zoophyte is like a living sheet of animal matter, fed and nourished by numerous mouths and as many stomachs. In some species the coalescence is confined to the lower half of the polyps, or to a still less part; and in this case the animals project above the general living surface. Polyps thus clustered, spreading at summit a star of tentacles, constitute the flowering zoophytes of coral reefs.

Those coral animals which do not bud are to all external appearance true actiniæ. The existence of coral in the living coral zoophyte is nowhere apparent, and would not be suspected if not previously known; for, as before stated, it is wholly internal, and the visible exterior is the fleshy skin of the polyp.

c. *Secretion of Coral.*—We have already remarked on the general nature of coral secretions. These secretions, it should be further observed, increase within simultaneously with growth, and every new animal adds to those previously formed. They go on throughout the sides and base of each polyp, excepting generally the exterior skin, as above stated; and the whole forms a calcareous framework penetrated by the animal tissues, some of these tissues corresponding to and occupying the cellules of the corallum, and others penetrating the solid parts in minute ramifications. Coral is also secreted between the radiating fleshy lamellæ of the internal cavity of the polyp, producing the radiated calcareous lamellæ which constitute the star of a cell. In the corallum of a Madrepora or an Astræa, each surface cell or star belonged to a separate polyp, and the star was formed as here explained.

It would lead to a too long digression from the main topic before us, to explain the principles upon which the forms of zoophytes depend. They are dwelt upon at length in another volume. In this place we may briefly allude to the principal varieties of form proceeding from the budding process, and to a single point in their mode of growth, upon which much of their importance in reef-making depends.

d. *Forms of Actinoid Zoophytes.*—Zoophytes imitate nearly every variety of vegetation. Trees of coral are well known; and although not emulating in size the oaks of our forests—for they do not exceed six or eight feet in height—they are gracefully branched, and the whole surface blooms with coral polyps in place of leaves and flowers. Shrubbery, tufts of rushes, beds of pinks, and feathery mosses, are most exactly imitated. Many species spread out in broad leaves or folia, and resemble some large leaved plant just unfolding; when alive, the surface of each leaf is covered with polyp flowers. The cactus, the lichen clinging to the rock, and the fungus in all its varieties, have their numerous representatives. Besides these forms imitating vegetation, there are gracefully modelled vases, some of which are three or four feet in diameter, made up of a net work of branches and branchlets, and sprigs of flowers. There are also solid coral hemispheres like domes among the vases and shrubbery, occasionally ten, or even twenty feet in diameter, whose symmetrical surface is gorgeously decked with polyp stars of purple and emerald green.*

All the many shapes proceed in each instance from a single germ, which grows and buds under a few simple laws of development, and thus gives origin either to the branch, the broad leaf, the column, or the hemisphere.

e. *Life and Death in Concurrent Progress.*—But the more massy forms would not exist, and others would be of diminutive size, were it not for a peculiar mode of growth which characterises most coral zoophytes.

Life and death are here in concurrent or parallel progress, a condition favoured by the existence of coral secretions. In some instances, a simple polyp, while growing at top and constantly lengthening itself upward, is dying at its lower extremity, leaving the base of the coral bare, and destitute of any living tissues. The polyp thus continues rising in height, and death progresses below at the same rate, till at last the live polyp may be at the extremity of a coral stem many times its own length. This process is illustrated by figures on pages 62 and 78 of the Report on Zoophytes.

In species which bud and form large groups, the same operation takes place. In some instances the summit polyp or polyps bud and grow, while at a certain distance below the summit, the work of death is going on and polyps are gradually disappearing. There is thus a certain interval of life, the length of which interval is different for different species. There are zoophytes which grow to a height of several feet, and still only the upper one or two inches are living. The recent polyps at the top of the column are active with life, and vigorous in reproduction, while the more aged below, having reached the fixed limits of their existence, are disappearing. The enduring coral remains and constitutes the basement or stage of action for future generation of polyps.

But this death is not in progress alone at the base of the column or branch. Generally the *whole interior* of a corallum is dead, a result of the same process with that just explained. Thus, a Madrepora, although the branch may be an inch in diameter, is alive only to a depth of a line or two, the growing polyps of the surface having progressively died at their lower or inner extremity as they increased outward.

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* See Dana's Report on Zoophytes, pp. 29 and 59–61.

The large domes of Astræas, which have been stated to attain sometimes a diameter of ten or twenty feet, and are alive over the whole surface, owing to a symmetrical and unlimited mode of budding, are nothing but lifeless coral throughout the interior. Could the living portion be separated, it would form a hemispherical shell of polyps, in most species about half an inch thick. In some Porites of the same size, the whole mass is lifeless, excepting the exterior for a sixth of an inch in depth.

With such a mode of increase, there is no necessary limit to the growth of zoophytes. The rising column may grow upward, until it nears the surface of the sea, when death ensues simply from exposure, and not from any failure in its powers of life. The huge domes may enlarge till the same exposure just mentioned causes the death of the summit, and leaves only the sides to grow, which may increase indefinitely. Moreover, it is evident that, if the land supporting the growing coral were very gradually sinking, the upward increase of the coral might still be without limit.

There is hence sufficient means provided for the production of coral material for islands, however numerous. These humble ministers of creative power might, without other attributes than those they now possess, have laid the foundations of continents, and covered them with mountain ranges. This remark requires no limitation if we allow the requisite time, and connect with the power of growth such other agencies, soon to be explained, as have been at work in the Pacific since the reefs were there in progress.

The death of the polyps about the base of a coral tree would expose it seemingly to immediate wear from the waters around it, and especially as the texture is usually porous. But nature is not without an expedient to prevent a catastrophe that would be destructive to a large part of growing zoophytes, and would prevent the indefinite increase just explained. The dead surface becomes the resting place of numberless small incrusting species of corals, besides Nullipores, Serpulas, and some molluscs. In many instances the lichen-like Nullipore grows at the same rate with the rate of death in the zoophyte, and keeps itself up to the very limit of the living part. The dead trunk of the forest becomes covered with lichens and fungi, or in tropical climes, with other foliage and various foreign flowers: so among the coral productions of the sea there are forms of life which replace the dying polyp. The process of wear is thus entirely prevented.

The older polyps, before death, often increase their coral secretions within, filling the pores occupied by the tissues, and rendering the corallum more solid; and this is another means by which the trees of coral growth, though of slender form, are increased in strength and endurance.

The facility with which polyps repair a wound, aids in carrying forward the results above described. The breaking of a branch is no serious injury to a zoophyte. There is often some degree of sensibility apparent throughout a clump, even when of considerable size, and the shock, therefore, may occasion the polyps to close. But in an hour, or perhaps much less time, their tentacles will have again expanded; and such as were torn by the fracture will be in the process of complete restoration to their former size and powers. The fragment broken off, dropping in a favourable place, would become the germ of another coral plant, its base cementing by means of coral secretions to the rock on which it might rest; or if still in contact with any part of the parent tree, it would be reunited and continue to grow as before. The coral zoophyte may be levelled by transported masses swept over by the waves; yet, like the trodden sod, it sprouts again, and continues to grow and flourish as before. The sod, however, has roots which are still unhurt; while the zoophyte, which may be dead at base, has a root—a source or centre of life—in every polyp that blossoms over its surface. Each animal might live and grow if separated from the rest, and would ultimately produce a mature zoophyte.

We close this review of the characters of coral animals, which is a mere abstract of the fuller descriptions in the General Report on Zoophytes, by alluding briefly to a second division of zoophytes, not yet touched upon, and also to the Hydroidea and Bryozoa, which are likewise coral-making animals.

The Alcyonoidea.—The polyps of the Alcyonium* group of zoophytes differ from those which have been occupying us, in having but eight tentacles, and these are fringed with minute papillæ. The organ-pipe coral (Tubipora), is of this kind. When expanded in the sea, a clump resembles a bed of pinks, or looks like a lilac-cluster that had been dropped in the water; and this resemblance extends to the colour and size of the flowers as well as their form.

Some of these zoophytes secrete lime and form a tube; and of this kind is the Tubipora. Others secrete only scattered granules of lime through the tissues; and still others are fleshy throughout. Many of them, besides forming granular calcareous secretions within the body of the polyp, give origin to a horny secretion at base, analogous to the epidermic secretions (hair-nails) of other animals; and this secretion receiving constant additions from the polyps as they are successively budded out, forms the axis of the growing branch. Of this character is the horny axis of the Gorgonia or sea-fan, which was long taken for a vegetable production. The crust which covers the axis consists of united polyps, which expand over its surface; and when expanded, each branch becomes a spike of flowers.

The Hydroidea.—The Hydroidea include the groups Hydra, Sertularia, Tubularia, and the allied. Some species form thready tufts and plumes of extreme delicacy, and others (the Hydræ) are simple polyps. The fine branchlets of the feathery species consist, when dead, of one or two series of microscopic cells arranged like tiny cups, tubes, or goblets, along the stem; and when alive, each cell is the site of a minute flower animal. A coronet of tentacles surrounds the mouth, as in the actiniæ, though somewhat different in character. The internal cavity is a simple tube without radiating lamellæ or special organs of reproduction, and the gemmules grow out singly or in bunches from the sides of the animal. The Hydra, an animal a line or two in length, consists of a tubular body, with a mouth at one extremity, surrounded by a circle of tentacles; and the structure of the animal is so simple that it may be turned inside out, and still live and eat; it may be cut into forty or more parts, and from the dissected body will grow as many distinct Hydræ. The Hydroidea are all minute, and act no important part in reef-making.

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* This name is derived from Alcyone, the fabled daughter of Neptune, and although from a Greek word, having the aspirate breathing to the first letter, it was written by the Latins as here (and by Linnæus and others), without the H.

The Hydroidea were long considered mature animals. But recent investigations have shewn that part at least develop Medusæ, which are properly the adult individuals, since these alone produce true ova. This division has therefore been recently removed from the zoophytes, and placed with the Acalephs or jelly-fishes.

The Bryozoa.—The Bryozoa are other coral-making species; but they are related to certain molluscs called Ascidiæ rather than to zoophytes. In habit and size, they much resemble the Hydroidea. From a minute cabin-like cell, they extend a circlet of slender arms or tentacles, and expand into a delicate goblet-shape flower, seldom over a line in diameter. These polyps differ, both from the Actinoidea and Hydroidea, in having two extremities to the alimentary canal—an anus, as well as a mouth; the intestine curves around and terminates in the disk. They are widely removed from true zoophytes, both by this character and also by having the tentacles furnished with vibratile cilia,—that is, minute appendages resembling short hairs, which are kept in nearly constant vibration. Some species of Bryozoa form thin crusts over rocks or sea-weeds, consisting of united cells, scarcely distinguishable unless magnified. The corolla of other species are branching or thin foliaceous; and these also consist of series of minute cells.

2. *Texture and Composition of Corals.*

The *texture* of calcareous corals is in general quite porous *or cellular.* Small stars or rounded depressions are scattered over the surface, and sometimes these stars form the centres of small prominences, called calicles (little cups). Besides the polyp cells, which mark the position each of a separate polyp, there are pores or cellules penetrating the texture of the coral mass; yet in some zoophytes, the coral secretions continue increasing in the animal till the pores are almost or quite obliterated, and the texture is nearly compact, the polyp cells alone remaining. In many species, wherever there are concavities of much depth in the surface of a zoophyte, the coral of these concavities is loose or more spongy than elsewhere, for the reason, apparently, that the polyps in such parts have a poorer chance for securing food and fresh portions of water.

In the Gorgoniæ, and other species forming a distinct axis to the branches, this axis is solid, without a trace of a cell, and usually with faint evidences of a concentric structure. It is thus that the red coral of commerce used in jewellery, differs from the Madrepore or common white coral; it is the axis of a species of Corallium; and the polyps constituted a layer about it, in the same manner as the polyps of Gorgoniæ cover the horny axis of these species.

In *hardness*, the common calcareous corals are a little above ordinary limestone or marble, the degree being represented in the mineralogical scale of Mohs, by 3·5 to 4, while in limestone it is about 3. The ringing sound given when coral is struck with a hammer, indicates this superior hardness. It is a common error of old date to suppose that coral when first removed from the water is soft, and afterwards hardens on exposure. But, in fact, there is scarcely an appreciable difference; the live coral has a slimy feel in the fingers, but if washed clean of the animal matter, it is found to be quite firm. The waters with which it is penetrated, may contain a trace of lime in solution, which evaporates on drying, and adds slightly to the strength of the coral, but the change is hardly appreciable. A branched madrepore rings on being struck when first collected; and a blow in any part puts in hazard every branch throughout it, on account of its elasticity and brittleness. Its specific gravity varies from 2·5 to 2·8:

2·523 was the average from fifteen specimens examined by Professor B. Silliman junior.*

In *composition*, the common reef corals, of which the branching Madrepora and the massive Astræas are good examples, consist almost wholly of carbonate of lime, the same ingredient which constitutes ordinary limestone. In 100 parts, 90 to 96 parts are of this constituent; of the remainder, there are 3 to 8 parts of organic matter, with some earthy ingredients, amounting in certain species to 2 parts, though often less than 1. These earthy ingredients are silica, magnesia, alumina, oxide of iron, phosphate of magnesia, and fluorides of magnesium and calcium. The following is the result of one of Mr Silliman's analyses from those made by him for the Report on Zoophytes.† The specimen was a Porites from the Sandwich Islands. It afforded,—Carbonate of lime, 95·84; Phosphates, fluorides, &c. 2·05; Organic matter, 2·11. The various earthy ingredients are included in the second line of the analyses, in this species, amounting to 2·05 per cent. One hundred parts of the same, subjected to exact analyses, gave the following result:—Silica, 22·00; Lime, 13·03; Magnesia, 7·66; Fluoride of calcium, 7·83; Fluoride of magnesium, 12·48; Phosphate of magnesia, 2·70; Alumina (and iron), 16·00; Oxide of iron, 18·30. In other analyses, similar results were obtained, with sometimes a larger proportion of fluorides.

The horny corals (axes of Gorgoniæ and Antipathi) were found by Hatchett to have nearly the constitution of ordinary horn.‡

The sea-water and the ordinary food of the polyps are evidently the source from which the ingredients of coral are obtained. As coral is an animal secretion, there is no good reason for the surprise with which this subject is sometimes approached. The same powers of elaboration which exist in other animals belong to polyps; for this function, as we have remarked, is the lowest attribute of vitality.

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* Report on Zoophytes, p. 713. On page 711, it is suggested by the author that the high degree of hardness, which characterises the corals and also the shells of many molluscs, may arise from the structure of the calcareous secretions being like that of Aragonite, instead of common calc spar. The hardness is near that of Aragonite, though sometimes a little exceeding it.

† Op. cit., p. 712, and this Journal (2), 1–189.

‡ *Report on* Zoophytes, p. 56.

Neither is it at all necessary to inquire whether the lime in sea-water exists as carbonate or sulphate, or whether chloride of calcium takes the place of these. The powers of life may make from the elements present whatever results the functions of the animal require.*

Various waters were collected in the vicinity of the coral islands, and at different distances from them, for the purpose of analysis, in order to compare the constitution of the sea in different parts; but they were lost with the Peacock on the bar of the Columbia river. The proportion of lime salts which occurs in the water of the ocean is about $\frac{1}{30}$ to $\frac{1}{35}$ of all the ingredients in solution. Professor Forchammer has ascertained that around the West Indian seas, where corals abound, lime is not as abundant as elsewhere in the ocean, the proportion, according to five analyses, being 247 to 10,000; while in the Kattegat, where the rivers of the Baltic carry it in considerable quantities, the proportion, from four analyses, is 371 to 10,000.† Schweitzer obtained the following results in water taken from the British Channel:‡—Water 964·74 grains; chloride of sodium, 27·06; chloride of potassium, 0·77; chloride of magnesium, 3·67; bromide of magnesium, 0·03; sulphate of magnesia, 2·29; sulphate of lime, 1·41; carbonate of lime, 0·03=1000·00.

Recently Dr G. Wilson has detected fluorine in sea-water, shewing that all the ingredients of coral are actually contained in the waters of the ocean.*

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* If a drop of sea-water be slowly evaporated under a microscope of high power, crystals of selenite (sulphate of lime) are produced, having the most common forms presented by native crystals of this mineral, as stated in works on mineralogy. On adding more water, they are again dissolved; and this may be repeated indefinitely. These results would seem to indicate that the lime was mostly in the state of a sulphate. Mr Darwin states the remarkable fact, described by Mr Webster (Voyage of the Chanticleer, ii., 319), that a deposit of salt and gypsum two feet thick occurs on the shores of Ascension, which was formed by the dash of the waves. Beautiful crystals of selenite were obtained by the writer in logs of half decomposed wood in the shore cliffs near Callao, which were of similar origin.

† On Comparative Analytical Researches on Sea-Water, by Prof. Forchammer, Rep. Brit. Assoc. for 1846, p. 90.

‡ Lond. and Ed. Phil. Mag. for July 1839, xv., 51; Amer. Jour. Sci., xxxviii., 12.

It has been common to attribute the origin of the lime of corals to the existence of carbonic acid springs in the vicinity of coral islands. But it is an objection to such a hypothesis, that, in the first place, the facts do not require it; and in the second, there is no foundation for it. The islands have been supposed to rest on volcanic summits, thus making one hypothesis the basis of another. Carbonic acid springs are by no means a universal attendant on volcanic action. The Pacific affords no one fact in support of such an opinion. There are none on Hawaii, where are the most active fires in Polynesia; and the many explorations of the Society and Navigator Islands have brought none to light. Some of the largest reefs of the Pacific, those of New Holland and New Caledonia, occur where there is no evidence of former volcanic action.†

The currents of the Pacific are constantly bearing new supplies of water over the growing coral beds, and the whole ocean is thus engaged in contributing to their nutriment. Fish, molluscs, and zoophytes are thus provided with earthy ingredients for their calcareous secretions, if their food fails of giving the necessary amount; and by means of the powers of animal life, bones, shells, and corals alike are formed.

The origin of the lime in solution throughout the ocean is an inquiry foreign to our present subject. It is sufficient here to shew that this lime, whatever its source, is adequate to explain all the results under consideration.

3. *Causes influencing the Growth of Coral Zoophytes.*

Marine zoophytes generally require pure ocean water, and they abound especially in the broad inner channels among the reefs, or the large lagoons, and in the shallow waters outside of the breakers. In these channels, at the Feejee group, there are species of every genus, and they grow in the greatest luxuriance, exceeding in profusion and display all that was elsewhere seen in the Pacific. Here are found the huge Astræa domes, the Meandrinas, Porites, the leafy clusters of the Merulinæ, numerous Madrepores:—indeed nearly all the Pacific corals described in the Report on Zoophytes, exclusive of those from the Tahitian and Hawaiian Islands, were obtained from the inner reefs of the Feejees.* It is therefore an assertion wide from the fact, that only smaller corals grow in the lagoons and channels, though true of lagoons and channels of small size, or of such parts of the larger channels as immediately adjoin the mouths of fresh-water streams.

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* Trans. Roy. Soc. of Edin., xvi., 145, 1846; Amer. Jour. Sci., 2d Ser., ii., 114, 1846.

† See also Darwin, *Op. cit.*, p. 60.

There are undoubtedly species especially fitted for the open ocean; but as peculiar conveniences are required for the collection of zoophytes outside of the line of breakers, we have not the facts necessary for an exact list of such species. From the very abundant masses of Astræas, Meandrinas, Porites, and Madreporas thrown up by the waves on the exposed reefs, it was evident that these genera were well represented in the outer seas. In the Paumotus, the single individuals of Porites lying upon the shores were at times six or eight feet in diameter. Around the Duke of York's Island the bottom was observed to be covered with small branching and foliaceous Madrepores (Manoporæ), as delicate as any of the species in more protected waters.

Species of the same genera grow in the face of the breakers, and some are identical with those that occur also in deeper waters. Numerous Astræas, Meandrinas, and Madreporas grow at the outer edge of the reefs, where the waves come tumbling in with their full force. There are also many Milleporas, and some Porites and Pocilloporas in the same places. But the weaker Manoporas, excepting incrusting species, are found in stiller waters, either deep or shallow. The Nullipores, properly calcareous vegetation, flourish best along the line of breakers, and form thick accumulations upon the reef.†

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* The author's observations on the *species* of corals were not commenced till reaching the Feejees, where we were among the *inner* reefs. Previous to that time, this department in zoology was in the hands of Mr J. P. Couthouy.

† Porites and Milleporæ, according to Mr Darwin, prevail on the surf-reef of Keeling's Island. Chamisso states that the large Astræas live and grow in the breakers.

Again, the same genera occur in the shallow waters of the reef inside of the breakers. Astræas, Meandrinas, and Pocilloporas are not uncommon, though requiring pure waters. There are also Madreporas, some growing even in impure waters. One species was the only coral observed in the lagoon of Honden Island (Paumotus), all others having disappeared, owing to its imperfect connection with the sea. Upon the reefs inclosing the harbour of Rewa (Viti Lebu), where a large river, 300 yards wide, empties, which during freshets enables vessels at anchor two and a-half miles off its mouth to dip up fresh water alongside, there is a single porous species of Madrepora (*M. cribripora*) growing here and there in patches over a surface of dead coral rock or sand. In similar places about other regions, species of Porites are most common. In many instances, the living Porites are seen standing six inches above low tide, where they were exposed to sunshine and to rains; and associated with them in such exposed situations, there were usually great numbers of Alcyonia and Xeniæ. Porites also occur in the impure waters adjoining the shores; and the massive species in such places, commonly spread out into flat disks, the top dying from the deposition of sediment upon it.

The exposure of six inches above low tide, where the tide is six feet, as in the Feejees, is of much shorter duration than in the Paumotus, where the tide is less than half this amount; and consequently the height of growing coral, as compared with low-tide level, varies with the height of the tides. The powers of endurance in some coral zoophytes cannot surprise us, for it is well known that these animals are often very tenacious of life. The hardier species belong mostly to the genera Porites and Pocillopora, besides the family Alcyonidæ.

The small lagoons, when shut out from the influx of the sea, are often rendered too salt for growing zoophytes, in consequence of evaporation,—a condition of the lagoon of Enderby's Island.

Coral zoophytes sometimes suffer injury from being near large fleshy Alcyonia, whose crowded, drooping branches *lying over* against them, destroy the polyps, and mar the *growing* mass. But Serpulas and certain species of barnacles, constituting the genus Criseis, fix themselves upon the living Astræa, Millepora, and other corals, and finally become imbedded by the increase of the zoophyte, without producing any defacement of the surface, or affecting its growth. Many of the Serpulas grow with the same rapidity as the zoophyte, and finally produce a long tube, which penetrates deep within the coral mass; and, when alive, they expand a large and brilliant circle or spiral of delicate rays, making a gorgeous display among the coral polyps. Instinct seems to guide these animals in selecting those corals which correspond with themselves in rate of growth; and there is in general a resemblance between the markings of a Criseis and the character of the radiations of the Astræa it inhabits.

The effects of sediment on growing zoophytes are strongly marked, and may be often perceived when a mingling of fresh water alone produces little influence. We have mentioned that the Porites are reduced to flattened masses by the lodgment of sediment. The same takes place with the hemispheres of Astræa; and it is not uncommon that in this way large areas at top are deprived of life. The other portions still live unaffected by the injury thus sustained. Even the Fungiæ, which are broad simple species, are occasionally destroyed over a part of the disk through the same cause, and yet the rest remains alive. Wherever streams or currents are moving or transporting sediment, there no corals grow; and for the same reason we find no living zoophytes upon sandy or muddy shores.

The influence of *temperature* on the development of animal life, and the distribution of species, is well known. But in no department is it more strikingly displayed than in that of zoophytes. In a former report we have considered the general influence of temperature on the several divisions of this order of animals. The remarks which follow are consequently confined to the *reef-forming* species. We reserve for still another page the influence of this cause on the distribution of reefs, since we are occupied here with zoophytes as animal species, and not with reefs,—a result from the growth of corals.

The temperature of the ocean in which reef-corals grow is evidently the temperature congenial to them. From a general survey of facts, it appears that these species are not met with where the winter temperature remains much time below 66° Fahr., though a temporary reduction to 64°, or perhaps lower (as the Bermudas), may sometimes occur. Where the temperature is above this, even in the hottest parts of the torrid zone, coral zoophytes thrive well. An isothermal line, crossing the ocean where this winter temperature of the sea is experienced, one north of the equator, and another south, bending in its course by divergence or convergence, wherever the marine currents change its position, will include all the growing reefs of the world; and the area of waters may be properly called the *coral-reef seas.* This *limiting* temperature is found near latitude 28°. Under the equator in the Pacific, the waters where warmest have the temperature 85° Fahr., and in the Atlantic 83° Fahr.; 66° to 85° is therefore not too great a range of temperature for the various reef-forming corals. Particular species, however, have similar limits; but these limits have not yet been accurately ascertained.*

The Porites and Pocilloporæ predominate at Oahu (Sandwich Islands), and there are but few of the Astræidæ,—a fact which appears to be explained on the ground that the reefs of that island are not far from the *cold* limits of the coral seas; and it is interesting to observe that these same corals are the hardiest under exposure to impure waters. The warmest parts of the ocean are favourable to the growth of Astræas, Meandrinas, and the allied species; and at the same time, these regions abound in Porites and Pocilloporæ, although the proportion of these corals is smaller than at Oahu.

The genera of reef-forming corals which occur out of the coral-reef seas, belong almost exclusively to the Caryophyllia family, and especially to the genera Dendrophyllia, Caryophyllia, Astroides,* Oculina, and Cyathina, some species of which exist in the Norwegian seas. The Gorgonidæ, Alcyonidæ, Hydroidea, and Actinidæ, extend from the equator nearly to the frigid zone. The Bryozoa have an equally wide range.†

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* The first application of the well-established principle that temperature influences the growth and distribution of corals is claimed by Mr J. P. Couthouy equally with myself. Any attempt, however, to determine a limiting temperature he declaims, and in this particular, as well as the conclusions arrived at, our views are very different. The facts and inferences stated in this place, *and on a following* page, are deduced throughout from my own study and *investigation.*

The liability of the lagoons, when contracted in size, to become highly heated by the sun, is probably one cause leading to the depopulation of these internal waters. The temperature becomes raised, as in a puddle of standing water elsewhere, and is quite unfitted, therefore, for species accustomed only to the ordinary tropical temperature of the ocean.

Light and pressure, and probably the amount of air in sea-water, influence the growth of corals so far as to fix limits to their distribution in *depth*. It is a little remarkable that those families which have a wide geographical range have also a great range in depth; for Carophylliæ, Dendrophylliæ, Oculinæ, Gorgonidæ, and Hydroidea, are found even at depths of one or two hundred fathoms; while Madrepores and Astræas, and all the ordinary reef-forming species scarcely exceed a depth of twenty fathoms.

Temperature has little or no influence in determining this range, although it has been so asserted; 66° is not met with under the equator short of 75 or 100 fathoms. The following table gives approximate results for the winter months from observations on this point by different navigators in the Pacific. It is well known that these averages are varied much in particular regions by currents.

Latitude.	Depth of 60° Fahrenheit.
N. Latitude 28° 30′	0–25 fathoms.
25°	25–30 „
20°	30–50 „
15°	40–60 „
10°	50–75 „
5°	75 „

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* The corals of the Astroides closely resemble those of the Astræa, and have been referred to the latter group by many authors. A related species is found on the coast of this country as high up as latitude 42°. An Astræa has been reported from Sydney, New South Wales, which, if a true Astræa (it has not been described or figured), gives this genus a wider limit than the coral-reef seas.

† See farther, Report on Zoophytes, p. 102.

Latitude.	Depth of 60° Fahrenheit.
EQUATOR 0°	75–100 fathoms.
S. Latitude 5°	50–75 ,,
10°	50 ,,
15°	50 ,,
20°	40 ,,
25°	25 ,,
28–30°	Surface.

It appears, therefore, that among the causes limiting the range of corals in depth, light and hydraulic pressure must have great influence. The proportion of atmospheric air present may be another cause. Yet, according to Darondeau, the deeper waters contain more atmospheric air, and also more carbonic acid,—the difference being as much as $\frac{1}{100}$th the volume of the water.*

Quoy and Gaymard were the first authors who ascertained that reef-forming corals were confined to small depths, contrary to the account of Forster and the early navigators. The mistake of previous voyagers was a natural one, for coral reefs were proved to stand in an unfathomable ocean; yet it was from the first a mere opinion, as the fact of corals growing at such depths had never been ascertained. It is now considered altogether probable that the bottom of the ocean in its deeper parts is mostly without life of any kind. The few Caryophylliæ, and other species which are met with in deep waters, have been shewn to be sparsely scattered, mostly of small size, and nowhere form accumulations or beds.

The above-mentioned authors, who explored the Pacific in the Uranie, under D'Urville,† concluded from their observations, that five or six fathoms (30 or 36 feet) limited their downward distribution. Ehrenberg, by his observations on the reefs of the Red Sea, confirmed the observations of Quoy and Gaymard; he concluded that living corals do not occur beyond six fathoms. Mr Stutchbury, after a visit to some of the Paumotus Tahiti, remarks, that the living clumps do not rise from a greater depth than 16 or 17 fathoms.‡

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* Examination of sea water, collected during the voyage of the Bonite.—Jameson's Edin. Jour., July 1838, p. 164.—*Darondeau*. Observations require confirmation.

† Afterwards also in the Astrolabe.

‡ S. Stutchbury, West of England Journal, i. 48.

Mr Darwin, who traversed the Pacific with Captain Fitzroy, R.N., gives 20 fathoms as not too great a range, and mentions reported instances of growing reefs in 25 or even 30 fathoms. He states that in the Red Sea, according to Captain Morehead, living corals occur at 25 fathoms. At Keeling Atoll growing corals are described by him as wholly disappearing beyond 20 fathoms; and at the Maldives and Chagos at a less depth. Other facts brought forward by Mr Darwin relate to Caryophylliæ, and those species which have a wide range beyond reef-forming zoophytes.

It thus appears that all recent investigators since Quoy and Gaymard have agreed in assigning a comparatively small depth to growing corals. The observations on this point, made during the cruise of the expedition, tend to confirm this opinion. The conclusion is borne out by the fact, that soundings in the course of the various and extensive surveys afford no evidence of growing coral beyond 20 fathoms. Where the depth was 15 fathoms, coral sand and fragments were almost uniformly reported. Among the Feejee Islands the extent of coral reef grounds surveyed was many hundreds of square miles, besides the more careful examination of harbours. The reefs of the Navigator Islands were also sounded out, with others at the Society group, besides numerous coral islands; and through all these regions no evidence was obtained of corals living at a greater depth than 15 or 20 fathoms. Within the reefs west of Viti Lebu, and Vanua Lebu, the anchor of the Peacock was dropped sixty times in water from 12 to 24 fathoms deep, and in no case struck among growing corals; it usually sunk into a muddy or sandy bottom. Patches of reef were encountered at times, but they were at a less depth than 12 fathoms. By means of a drag, occasionally dropped in the same channels, some fleshy Alcyonia, and a few Hydroidea were brought up, but no reef-forming species.

Outside of the reef of Upolu corals were seen by the writer growing in 12 fathoms. Lieutenant Emmons brought up with a boat anchor a large Dendrophyllia from a depth of 14½ fathoms at the Feejees; and this species was afterwards found near the surface. Dendrophyllia, it may be remembered, is one of the deep water genera.

These facts, it may be said, are only negative, as the sounding lead, especially in the manner it is thrown in surveys, would fail of giving decisive results. The character of a growing coral bed is so strongly marked in its uneven surface, its deep holes and many entangling stems, to the vexation of the surveyor, that in general the danger of mistake is small. But allowing uncertainty as great as supposed, there can be little doubt after so numerous observations over so extended regions of reefs.

The depth of the water in harbours and about shores where there is no coral confirms the view here presented. At Upolu the depth of the harbours varies generally from 12 to 20 fathoms. On the south side of this island Lieutenant Perry, off Falealili, one hundred yards from the rocky shores, found bare rocks in 18 and 19 fathoms, with no evidence of coral. There is no cause here which will explain the absence of coral, except the depth of water; for corals and coral reefs abound on most other parts of Upolu. Below Falelatai, off the same island, an equal depth was found, with no coral. Off the east cape of Falifa harbour, on the north side of Upolu, Lieutenant Emmons found no coral, although the depth was but 18 fathoms. About the outer capes of Fungasar harbour, Tutuila, there was no coral, with a depth of 15 to 20 fathoms; and a line of soundings across from cape to cape, afforded a bottom of sand and shells, in 15 to 21½ fathoms. About the capes of Oafonu harbour, on the same island, there was no coral, with a depth of 15 fathoms.

Similar results were obtained about all the islands surveyed, as the charts satisfactorily shew. There is hence little room to doubt that 20 fathoms may be received as near the range in depth for reef corals; and probably the limit lies between 15 and 20 fathoms, or not far from 100 feet.

It may be here remarked, that soundings with reference to this subject are liable to be incorrectly reported by persons who have not particularly studied living zoophytes. It is of the utmost importance, in order that an observation supposed to prove the occurrence of living coral should be of any value, that it be unequivocally determined whether the fragments, which a lead may bring up, are alive or not when broken off; for a dead fragment proves nothing. Even a strong impression upon the lead, shewing the form and character of the surface cells of a coral is not wholly satisfactory, as it may have been given by a mass not living. A living fragment, placed in water, will be seen to have a fleshy surface, even if the polyps do not expand. The best observations, with reference to this subject, would be made with a diving bell.

Much yet remains for further investigation. Mr Edward Forbes, in his Zoological Explorations of the Ægean, distinguished three separate regions of invertebrate species within 20 fathoms of the surface: the *first*, or littoral, extending to 2 fathoms in depth; the *second* from 2 to 10 fathoms; the *third* from 10 to 20 fathoms.* Similar subdivisions, or others on the same general principle, may yet be detected in the Pacific, indicated perhaps by zoophytes as well as molluscs. There is no evidence, however, that there are successive beds, composed of a distinct set of species, as has been sometimes suggested. The upraised reefs of Metia afford no proofs of such a mode of formation; on the contrary, they shew that the process is continuous and uniform in character through the reef-growing depths. The species in the lower part of the 16 fathoms are probably different from many of those above; but they pertain to the same genera in most instances, and moreover there are no abrupt transitions, consequently the resulting reefs should have a nearly uniform character, as here stated. This fact may be better appreciated after perusing the following chapter.

The Nullipore zone along the reef-line, between low and high tide, is clearly made out by Mr Darwin, and is one of the interesting results of his investigations. It performs a very important part, by the protection it gives the reef from abrasion. The exposed reef is thus gathering lime from the waters, and extending itself; when, if devoid of this protection, it would be constantly yielding to the sea. On the inner reefs, where the protection is not needed, it is not given.

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* On the Ægean Invertebrata. E. Forbes, Rep. Brit. Assoc. for 1843, p. 154.

Some species of Nullipore, however, occur in these regions, and others are found at various depths.

As the Caryophyllia family extend into deeper waters than most other reef corals, it might be inferred that these at least may constitute a lower bed, or substratum. But this is by no means the case. As just stated, one species (the Dendrophyllia nigrescens) was found at 14½ fathoms, and also of identical characters at low tide level. The Caryophylliæ are but sparingly distributed; the species are few, and mostly small, and not a dozen different kinds were detected in the Pacific. Their contributions to reefs are therefore inconsiderable.

4. *Rate of Growth of Zoophytes.*

The rate of growth of zoophytes is a subject but little understood. We do not refer here to the progress of a reef in formation, which is another question complicated by many co-operating causes; but simply to the rapidity with which particular species of coral zoophytes increase in size. There is no doubt that the rate is different for different species. It is moreover probable that it corresponds with the rate of growth of other allied polyps that do not secrete lime. The rate of growth of Actiniæ might give us an approximation to the rate of growth in a Mussa, which are coral animals of like size and general characters; for the additional function of secreting lime would not retard necessarily the maturing of the polyp; and from the rate of growth of the same animals in the young state we might perhaps draw some inferences as to the rate in polyps of corresponding size. But no observations on this point were made by us while abroad.

Although the rapidity is undoubtedly far less than was formerly reported, the following facts from different sources, seem to shew that the rate is still greater than has been of late believed. Mr Darwin, citing from a manuscript by Dr Allen of Forres, some experiments made on the east coast of Madagascar, states, that in December 1830 twenty corals were placed by this gentleman apart on a sandbank, in three feet water (low tide), and in the July following each had nearly reached the surface, and was quite immovable, and some had grown over the others. Mr Stutchbury describes a specimen, consisting of a species of oyster, whose age could not be over two years, encrusted by an Agaricia, weighing two pounds nine ounces.* It is stated by M. Duchassaing, in a letter from Guadeloupe, that in two months some large individuals of the *Madrepora prolifera*, which he broke away, were restored to their original size.†

Since the return of the expedition I have received a letter containing some facts on the growth of Actiniæ from Sir J. G. Dalyell, whose able observations in this department of science are highly curious and important. After speaking of the various conditions and sizes of the young at birth, and of the difference in the rapidity of growth depending on the amount of nutriment at hand, he says, speaking of a Scottish species of Actinia, "The dimensions will generally double in a fortnight from its birth. The diameter of the base being originally about an eighth of an inch, or hardly as much, will be five-eighths in six months; and the tentacles will occupy a circle of an inch and a-half in diameter. In twelve or thirteen months the diameter of the base will reach an inch, and the expansion of the tentacles two inches between the tips. An Actinia, whose tentacula expanded a quarter of an inch three weeks after it was produced, enlarged so much in five months that they expanded an inch, and the body was then half an inch thick." If we reason upon these data, and assume that the Madrepore polyps may increase lineally in six months as much as the young Actinia, we shall have an elongation of five-eighths, or three-fourths of an inch in six months. Taking the still more rapid rate of doubling in a fortnight, which might be more correct, since the Madrepore polyps are about the size of the Actinia in its earliest state, we should have a lengthening of a fourth of an inch in a month, and three inches a year. The data upon which this conclusion is based, though important, are uncertain, but would probably give too high rather than too low an estimate. And yet it is far below the rate apparently established by the experiments with corals cited in the preceding paragraph. We must admit that the subject requires more accurate investigation.

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* West of England Journal, vol. i., p. 50.

† L'Institut, No. 639, April 1, 1846, p. 111.

The stay of the expedition near any particular reef in the Pacific was too short for any examinations by us. They might easily be made by those residing in coral seas, either in the manner adopted by Mr Allan, or more definitely by placing marks upon particular species. By inserting slender glass pins a certain distance from the summit of a Madrepore, its growth might be accurately measured from month to month. Two such pins in the surface of an Astræa would in the same manner, by the enlarging distance between, shew the rate of increase in the circumference of the hemisphere; or, if four were placed so as to enclose an area, and the number of polyps counted, the numerical increase of polyps resulting from budding, might be ascertained. It is to be hoped that some of the foreign residents at the Sandwich, Society, Samoan, or Feejee Islands, will take this subject in hand. There are also many parts of the West Indies where these investigations might be conveniently made.

(To be continued.)

On the Colour of the Rocks in the Lake District of the North of England. By JOHN DAVY, M.D., F.R.S., &c. Communicated by the Author.

The careful observer in passing through the lake district of Westmoreland and the adjoining counties, can hardly fail of being struck by the prevailing dark hues of the rocks, often in so great a degree as to be almost black, and of having his curiosity excited as to the cause.

If he break a portion, he will commonly find the very dark hue to be superficial, or at least almost invariably of greater intensity at the surface than in the interior; and he will probably arrive at the conclusion, that this darker hue is a stain or discolouration imparted by adhering adventitious matter.

This conclusion I believe to be the correct one. I shall mention some circumstances which appear to confirm it.

First, Of the rocks of the district. These, for the most part, are varieties of clay-slate, more or less modified by metamorphic agencies. Their colour, as exhibited by a fresh fracture, is grey of different shades, owing chiefly to the presence of a minute portion of carbonaceous matter. Accordingly, when exposed to the action of an open fire, the grey hue is destroyed. Its colour is changed to shades, commonly light, of red or yellow, from the combustion of the carbonaceous matter, and the conversion of some protoxide of iron,—an oxide seldom entirely absent from the composition of these rocks,—into peroxide. And the effect of weathering—of long exposure to the atmosphere,—is similar, where the circumstances are such as to permit of its being witnessed without interference of adventitious causes,—as in the instance of rocks subjected to the action of torrents when the streams they skirt are flooded, and that so frequently as to prevent the growth of the lower order of plants on their surface.

Secondly, Of the nature of the discolouring matter. When abraded and placed under the microscope, it is found to be composed in most instances of granular matter like that of soot, and of fibres and cells like those afforded by the lower order of vegetables, such as the mucors, lichens, and mosses in a state of change, analogous probably to that by which peat is formed from the same class of plants. Further, ignited in the open air, the colouring matter burns, and is consumed, leaving only a very little ash.

Considering the composition of the rocks of the district, as adverted to, and these results, are we not justified in the conclusion that the discolouration is adventitious; and, moreover, that it is occasioned partly by a substance resembling soot, and partly by vegetable matter of a peaty character.

The source of the latter matter is easily found, the tendency to form peat being always to be observed in this climate wherever the local circumstances favour, such as moderate moisture, water more or less stagnant, shade, and lowness of atmospheric temperature. The rocks, the surface of which are most discoloured,—are of the darkest hues,—are so situated as to be under the influence of these circumstances, especially the " watery rocks," an expressive term of our great poet—rocks over which water oozing from the ground above, commonly peaty and mossy, not being absorbed, flows so slowly as barely to keep the surface wet; and also the rocks on the shores of the lakes and mountain tarns, more or less washed and kept wet by the waves breaking on them, or by drifting spray, and likewise the rocks in the beds, or on the sides of streams which, from fluctuations of level, are rarely long under water, and yet seldom perfectly dry. In these latter situations, it may be remarked, the remains of aquatic plants and of infusoria are to be detected in the colouring matter, as well as soot-like granules.

The source of the soot-like matter is not so obvious. In a former number of this Journal, that for July 1844, I have given an account of "a carbonaceous deposit or film, on the Lakes of Westmoreland." That deposit was shewn to be of the nature of soot, and was inferred to be derived from the adjoining manufacturing districts, wafted here by the wind, and falling with mist or gentle rain with a lull of wind. The observations which I have since made, have been confirmatory of this inference, and tending to prove that such precipitation of soot is an ordinary, rather than an uncommon or accidental occurrence here, and adequate therefore to the effect supposed. One confirmatory instance may suffice,—it is that of the discolouration of the sheep of the country, especially after exposure for weeks or months on the higher fells. Seen on their mountain pastures, or when driven into the lower meadows in the early spring, their coats are of so dark a hue as to resemble closely those of their fellows fed in the most smoky precincts of our great towns; and, on examination, the colouring matter staining the fleece, is found to be similar to that of the black film of the lakes and tarns; and in brief, essentially soot.

What I have described, may seem disparaging to the lake district, "the staple" of which has been poetically defined to be "its beauty." This I can hardly admit; contrast conduces to pleasing effects; dark rocks, and bright verdure are not incongruous on the mountain fell, no more than are the black shores and blue waters of the mountain tarns, or the pure white of the new born lamb by the side of its dark mother. The contrast almost surprises, and surprise commonly pleases; moreover, it ought not to pass unobserved, that the discolouring effects described, however prevalent, are not universal, and that they are often intermixed with brighter hues, tints of red, orange, and white, derived from the lichens which spread over the rocks of drier surfaces, and enhance the variety and beauty of the colouring.

In another point of view, in relation to the influence of atmosphere, it may be a question, whether the salubrity of air of this district may not be impaired by the cause adverted to. If it be, it is probably in so small a degree, as not to be appreciable. The good to the town or crowded district from which the fuliginous vapours are removed no doubt preponderates greatly over any possible evil to the country. Benefit may even result to the latter, from the precipitation of the matter of these vapours, in their fertilizing effects on the upland pastures. Thus considered may they not be viewed as an example of the equalizing, moderating tendencies, which belong to the economy of nature, in which, when sufficiently scrutinized no real waste of means can be detected, nor loss of substance?

LESKETH HOW, AMBLESIDE,
September 26, 1851.

Some views respecting the Source of Light, &c. By JAMES NASMYTH, Esq., F.R.A.S.

Impressed with the conviction that the progress of science has often been most importantly advanced by the setting forth of hypothetical views as to the nature of those causes which result in great phenomena, I am, for these reasons, induced to hazard and venture forth with some views on the subject of the nature of the solar light, more especially in reference to the well known but most remarkable phenomena occurring in the case of stars of variable and transitory brightness, as also in reference to those wonderful results of geological research, namely, the unquestionable evidence of the existence of an arctic or glacial climate in regions where such cannot now naturally exist; thus giving evidence of the existence of a condition of climate, for the explanation of which we look in vain to any at present known cause.

I must plead the fact of the existence of such wonderful phenomena as those alluded to, as my apology for thus attempting to come forth with what, although they may appear crude, theoretical notions, yet may, as tending to direct increased attention to important phenomena, so lead in due time to the development of truth, and extend the present bounds of our knowledge to those mighty laws which are so mysteriously indicated by the existence of the phenomena in question, and with the evidences of which we are yet surrounded.

A course of observations on the solar spots and on the remarkable features which from time to time appear on the sun's surface, which I have examined with considerable assiduity for several years, had in the first place led me to entertain the following conclusion, namely, that whatever be the nature of solar light, its main source appears to result from an action induced on the *exterior surface* of the solar sphere,—a conclusion in which I doubt not all who have attentively pursued observations on the structure of the sun's surface, will agree.

Impressed with the correctness of this conclusion, I was led to consider whether we might not reasonably consider the true source of the latent element of light to reside, *not in the solar orb*, but in space itself; and that the grand function and duty of the sun was to act as an agent for the bringing forth into vivid existence its due portion of the illuminating or luciferous element, which element I suppose to be diffused throughout the boundless regions of space, and which, in that case, must be perfectly exhaustless.

Assuming, therefore, that the sun's light is the result of some peculiar action by which it brings forth into *visible* existence the element of light, which I conceive to be latent in, and diffused throughout, space, we have but to imagine the existence of a very probable condition, namely, the *unequal* diffusion of this light-yielding element, to catch a glimpse of a reason why our sun may, in common with his solar brotherhood, in some portions of his vast stellar orbit, *have passed,* and may yet have to pass, through regions of space in which the light-yielding element may either abound or be deficient, and so cause him to beam forth with increased splendour, or fade in brilliancy, just in proportion to the richness or poverty of this supposed light-yielding element as may occur in those regions of space through which our sun, in common with every stellar orb, has passed, is now passing, or is destined to pass, in following up their mighty orbits.

Once admit that this light-yielding element resides in *space*, and that it is not equally diffused, we may then catch a glimpse of the cause of the variable and transitory brightness of stars, and more especially of those which have been known to beam forth with such extraordinary splendour, and have again so mysteriously faded away; many instances of which abound in historical record.

Finally, in reference to such a state of change having come over our sun, as indicated by the existence of a glacial period as is now placed beyond doubt by geological research, it appears to me no very wild stretch of analogy to suppose, that in such former periods of the earth's history, our sun may have passed through portions of his stellar orbit in which the light-yielding element was deficient, and in which case his brilliancy would have suffered the while, and an arctic climate in consequence spread from the poles towards the equator, and leave the record of such a condition in glacial handwriting on the everlasting walls of our mountain ravines, of which there is such abundant and unquestionable evidence. As before said, it is the existence of such facts as we have in stars of transitory brightness, and the above-named evidence of an arctic climate existing in what are now genial climates, that renders some adequate cause to be looked for. I have accordingly hazarded the preceding remarks as suggestive of a cause, in the hope that the subject may receive that attention which its deep interest entitles it to obtain.

This view of the source of light, as respects the existence of the luciferous element throughout space, accords with the Mosaic account of creation, in so far as that light is described as having been created in the first instance *before the sun* was called forth.

Report on the Investigation of British Marine Zoology by means of the Dredge. Part I. *The Infra-littoral Distribution of Marine Invertebrata on the Southern, Western, and Northern Coasts of Great Britain.* By Professor EDWARD FORBES.

(*Continued from page* 391 *of Vol. LI. of Philosophical Journal.*)

Gregarious and prolific species.—Many of our littoral mollusca, as the shore-living species of *Littorina*, *Purpura*, *Trochus*, *Cardium*, *Donax*, *Mya*, *Pholas*, &c., are truly gregarious, and the individuals of each are constantly found assembled together in considerable numbers. This is not so commonly the habit among sub-littoral species; among them, however, there are some habitually gregarious (as *Ostrea edulis*, &c., and among radiata, *Ophiura rosula*, *Uraster rubens*, *Comatula europæa*, *Echenus sphæra*), though with this difference as compared with the most littoral gregarious forms, that whereas the individuals of the latter are always assembled together, the sub-littoral species are gregarious in some zones of depth and under certain conditions of sea-bottom, while they are at the same time diffused in small numbers, or even as solitary individuals in situations where the conditions do not seem so favourable to fecundity. Many species also, not at all gregarious in the true sense of the word, having a very wide range in depth, are not equally prolific throughout that range, but are developed in much greater numbers in one region than in another, or in different parts of the same region, according to the conditions of the sea-bed. Climatal differences also have a considerable effect in determining the prolific or non-prolific character of a species, and this may be observed clearly, even in such a limited area as that under review. Hence, when we state of many species that they are diffused throughout all the provinces of that area, it is not to be understood that they are equally abundant, so far as their individuals are concerned, in all. Thus, for example, *Dentalium entalis* is distributed throughout the British seas; but whilst it is so abundant as to be almost gregarious in the northern provinces, it becomes scarce and solitary in the southern. Many examples of this may be seen by consulting the analysis of dredging papers in the preceding tables, and afterwards comparing them with the tables of enumeration of localities of species.

In the Littoral region, as mentioned already, the species of *Littorina*, *Trochus*, *Patella*, and *Purpura* are most abundant, and among bivalves, *Mytilus edulis*, *Cardium edule*, and *Kellia rubra*. These with many other animals, and with peculiar marine plants, give a character to the sea-belt between the tide-mark.

In the Laminarian region, extending from low water-mark to 15 fathoms or thereabouts, *Lacunæ* and *Rissoæ* are abundant.

Between 15 and 25 fathoms in the upper part of the Coralline zone, *Trochus ziziphinus*, &c., abound in individuals on the English shores.

Between 25 and 40 fathoms, in the middle and lower sections of the Coralline region, the species observed most prolific in individuals on the English coast were few, comprehending *Solen pellucidus*, *Pecten varius*, *Modiola modiolus*, and *Dentalium tarentinum.*

On the Scottish coast this region is remarkable for prolific and peculiar species. Great numbers of Brachiopoda (*Terebratula Caput-serpentis*, and *Crania norvegica*) are found in gravelly and stony places. *Dentalium entalis*, *Nucula nucleus*, *Astarte sulcata*, *Leda caudata*, and (in places) *L. pygmæa*, *Mactra elliptica*, and *Modiola modiolus*, are all very prolific.

Between 40 and 60 fathoms, on the verge of the region of deep-sea corals, we have too little experience on the English coast to judge. *Cardium suecicum*, however, essentially a northern form, was noted as abundant at a depth of 50 fathoms between Cornwall and Ireland.

In the Scottish seas between these depths, besides most of the species noted as prolific in the last region, we find *Nucula tenuis*, *Cardium suecicum*, *Nucula decussata* (locally), and *Venus fasciata* abundant; also, *Turritella* in places. Below that depth, *Leda caudata*, *Syndosmya intermedia*, *Venus ovata* and *striatula* (var.), *Lucina spinifera*, *Dentalium entalis*, *Turritella*, *Ditrupa*, and *Echinus norvegicus*, have been taken in considerable numbers in several Scottish localities. Widely diffused species of *Turritella*, *Dentalium*, *Modiola*, *Nucula*, *Venus*, and *Astarte*, appear to be most prolific throughout the range of their distribution.

Generic and subgeneric groups confined to particular zones in depth.—In the Littoral and Laminarian zones, we find all the species of certain well marked natural groups assembled, but very few, if any, of those which are distributed in the regions of corallines and of deep-sea corals are peculiar, the species of mollusks, in the lower zones especially, being members of genera which have representatives in the Laminarian or in both Littoral and Laminarian zones.

Relation of colour to distribution.—Although the extent and depth of our seas scarcely afford sufficient data for illustrating the influence of light in the colouring of marine animals, yet some facts bearing on this subject may be gathered from the papers before us. In the horizontal diffusion of species, several, as some of the *Trochi* and *Veneridæ*, exhibit a distinct influence of light upon the brightness of their hues in the south, as compared with the dull aspect of specimens from the north, and this in individuals of the same species. It is easy for the practised conchologist to distinguish specimens of most painted shells, gathered on the southern coasts of England, from those taken on other parts of our shores. We have evidence also of the distinct effect of depth in the defacing of the hues of the same species, when it has a great bathymetrical range. Thus, the examples of *Venus striatula*, *Venus ovata*, and *Turritella terebra* (all having a range from the Laminarian zone to the deepest recesses of the British seas), taken alive at a depth of 100 fathoms off the Zetland Isles by Mr MacAndrew, were colourless; whilst those from more moderate and shallow depths are almost always conspicuously coloured. Between 60 and 80 fathoms in the Scottish seas, dirty white, dull red, yellow or brown, rarely broken into stripes or bands, are the prevailing hues of the testacea; though at 50 fathoms, shells painted in patterns and vividly coloured (as *Natica Alderi* and *Clavatula purpurea*), exhibit their hues unimpaired. At the same time it must not be forgotten that the vividly painted animal of the coral *Caryophyllia* thrives at a depth of 80 fathoms. A curious phenomenon apparently connected with depth is the blindness of the crustacean *Calocaris*.

Condition of the exuviæ of marine invertebrata taken in the dredge.—In the great majority of instances and places, the dead shells of mollusca are taken nearly entire, or, in the case of the bivalves, with the valves disunited but not broken. This applies especially to all localities of a considerable depth, and where strong currents are not in action. Very near the shore, broken shells are not uncommon; and in current-ways, even at the depth of 30 fathoms, the bottom may be composed in great part of triturated shells. Lieut. Thomas, R.N., observes, when communicating his lists of Testacea dredged around the Orkney Islands, that "between Fair Island and the Orkneys, the bottom near the latter islands is either rocky or composed of large pieces of *Modiola modiolus* or *Pectunculus glycimeris*. I make no doubt," he remarks "that these are broken by some large species of Crustacea (?); their freshness of fracture is astonishing, as if the creature feeding had been disturbed at his meal." Among bivalves, besides those mentioned, the shells of *Thracia*, *Cyprina*, *Isocardia*, and the larger species of *Cardium*, are most frequently found broken; among univalves, those of *Buccinum* and *Fusus*. Some few bivalves are frequently dredged dead, yet with their valves united; such are *Lucina radula*, the *Neæræ*, *Mactra elliptica*, *Psammobiæ*, *Venus ovata* and *striatula*, *Tapes virginea*, *Tellina donacina*, *Thracia phaseolina*, *Lucinopsis*, *Nucula pygmæa*, *Solens*, *Syndosmyæ*, and *Pectunculus pilosus*, this last open and gaping. The monomyarious bivalves are often found dead in quantities, but almost always with valves disunited; and this may be said of the great majority of dimyarious bivalves also. Echinoderms fall to pieces when dead, or if taken entire have lost their spines.

Phenomena of the horizontal distribution of species on the western shores of Great Britain.—In the older accounts of British marine animals, the phrase "from Devon to Zetland" was frequently given as marking their range, and the natural inference from such statement was that such species were universally diffused through our seas. The researches embodied in this Report, however, put beyond question the fact that there are marked peculiarities in the distribution of British marine animals, and that though there are numerous species common to the whole area, there are also numerous species peculiar to parts of that area. We have clear evidence of more elements than one contributing to the composition of our submarine population, of a southern element, derived from the Lusitanian provinces of the European seas, of a northern element introduced from the Scandinavian seas, of a Celtic element having its centre within our own region, of an oceanic element manifested by the floating Gasteropoda and the Pteropoda that reach our shores, and of an arctic element due to causes which were in action before the British Isles had assumed their present conformation.* The following statements, founded mainly on the data contained in the tables, will serve to illustrate the phenomena, as far as this Report is concerned.

The northern and southern provinces of the western coast of Great Britain may be distinguished by certain Mollusca of the Littoral Zone, enumerated in the Report.

The differences between the northern and southern provinces are equally shewn by the sub-littoral testacea, as shewn in the Report.

Numerical comparisons of the Testacea and hard Echinodermata inhabiting the regions explored, with the total number of British species.—In the Report, one of the striking features is the small number of testacea and hard echinoderms inhabiting the British Seas, which do not live upon the western shores of Great Britain; such as are beyond their limits, are either of excessively southern and scarcely British character, as *Haliotis tuberculata*, *Jeffreysia opalina*, *Rissoa lactea*, and *Murex corallinus*; or oceanic forms of *Ianthina*, *Hyalæa*, and *Spirialis*; or species probably of arctic origin, extending only to our north-eastern coasts, as *Fusus norvegicus* and *Turtoni*, *Natica. Kingii*, *Hypothyris psittacea*, and *Goniaster equestris*. The number of doubtful or not sufficiently investigated forms is also very small. A considerable number of genera have no, or few, representative members in the Scottish and English columns of western sub-littoral species; these are either extra-limital, as *Hyalæa*, *Haliotis*, and *Hypothyris*; or excessively rare in our seas, as *Avicula*, *Stylifer*, *Cidaris*, and *Astrophyton*; or oceanic, as *Ianthina* and *Spirialis*; or wholly or mainly littoral, as *Littorina*, *Otina*, *Conovulus*, *Truncatella*, *Jeffreysia*, *Skenea* (proper), *Patella*, *Pleurobranchus*, *Teredo*, *Xylophaga*, *Petricola*, *Venerupis*, *Ceratisolen*, *Turtonia*, *Galeomma*, *Mytilus*, *Asterina*. In

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* See the Memoir on the British Fauna and Flora, in the first volume of the Memoirs of the Geological Survey.

Odostomia we have a genus which is not fairly represented, on account of the excessively critical character of its species. Five genera of Gasteropoda, three of Lamellibranchiate acephala, three of Palliobranchiate acephala, and three of hard Echinodermata, all having members in the Scottish portion of the regions explored, are without representatives in the English western and southern provinces. On the other hand, seven genera of Gasteropoda and eight of Lamellibranchiate acephala having English representatives, are altogether wanting on the western and northern coasts of Scotland. All our brachiopods found within the area explored are Scottish species ; the number of monomyarious Lamellibranchiata is slightly in favour of Scotland over England, which, however, shews a considerable majority of dimyaria. The proportion of Gasteropoda in the Scottish seas is, however, so great, that the total number of testacea is in favour of the north. This is to be attributed partly to the greater variety of depths and ground, and partly to the presence in the north of isolated colonies of arctic forms which swell the ranks of the inhabitants of those regions to beyond their natural proportions.

Whirlwinds produced by the Burning of Cane-Brakes.

Mr Olmsted read to the American Association, at New Haven, a paper on whirlwinds produced by the burning of cane-brakes in the south. The canes in Alabama often grow to the height of 35 or 40 feet. They are cut down, and, after drying for about six weeks, fire is applied to them in several places. As soon as the canes begin to burn, the air that is confined in their cells, and the watery vapour, burst them asunder. They generally explode through several cells at once, and thus are split in one continued line. Those explosions, in burning a large cane-brake, produce a continued roar, like the discharge of musketry from an immense army. On account of the dry, combustible nature of the cane, when kindled, the fire advances with great rapidity, giving out flames of the deepest red, the intensity and richness of which colour are incomparably finer than the flames which arise from the combustion of any other kind of wood. Together with the flame, there ascends a very dense, black smoke, resembling that which arises from burning camphor, or from the chimneys of gas-works or factories where bituminous coal is used. This smoke also far surpassed, in its dense, deep black colour, any thing ordinarily observed.

The cane-brake visited by Mr Olmsted covered a space of 25 acres, and was set on fire at the part most distant from him. " Whirlwinds were now observed in the hottest part of the fire. They did not unite in one column, but were scattered throughout the fire, and several were formed at the same time. The first were on a comparatively small scale. Their height was from 30 to 40 feet. To these succeeded others on a larger scale, until they reached the height of more than 200 feet, and the flame and smoke which formed their columns were perfectly distinct from the general mass which arose from the fire. They appeared rather to increase in size and frequency toward the latter part of the 'burning,' and many were formed on the ashes after the fire had to a great extent gone down.

" Among the whirlwinds there were several points of difference, by which they might be classed under four heads. The most common one was that which was stationary over a part of the fire which was hotter than the neighbouring portions. A second variety was that which had a progressive motion, and advanced over the burnt track, throwing up ashes and cinders, and thus making its course through the fire. Some of these emerged from the flames. This was probably the case with a number, although, having nothing to mark them after leaving the fire, they became invisible. One, however, passed near enough to us to be observed, and attracted our attention by its rustling sound, and by the leaves which it carried up. This was about 15 or 20 feet high. At the time this passed us we had moved from our first station, and were about 300 yards from the fire. These whirlwinds differed from the others in form, being very wide at the top, and contracting to a point at the bottom, like a top or a spindle; or, more exactly, they were of the form of the upper cone of an hour-glass. An interesting phenomenon which attended some of the whirlwinds might render it proper to arrange them under a third class. In these the flame was violently whirled at the base; then above succeeded a dark interval, where the flame seemed to be extinguished entirely, but towards the top it broke out anew. It was a mixed whirling of flame and smoke, the smoke occupying the central portion. The dark interval where the smoke was unconsumed was greater or less, as the flame above approached to, or receded from, that beneath. There were a number of this class. The fourth kind were formed of immense columns of smoke, so narrow and lofty that they resembled towers of several hundred feet, or trunks like those of trees in form, extending into the sky. The rotary motion was obvious throughout their entire length. These columns of smoke were generally straight, but sometimes bent at the top by the wind. In connection with the whirlwinds there were several other facts of interest observed during the burning of the cane. We noticed the direction of the wind was changed. At first it was from the north-east, and continued in that direction in the upper part of the atmosphere, as was evident from the way in which the columns of smoke were bent. But shortly after the commencement of the burning the air beneath blew in all directions towards the centre of the fire. The columns of smoke were not bent for more than a hundred yards; hence up to that height the wind blew in all directions towards the centre of the fire. These whirlwinds revolved on their axes from right to left, and from left to right, without any prevailing tendency to one direction more than to the other. Frequently the same whirlwind would change the direction in which it revolved, and would again return to its first course. In a few instances this was repeated several times. The charred leaves of cane being thin and light, were driven off in considerable quantities. They were carried up frequently without being burned, and were sometimes found at a distance from the place of the fire. But considering the extent of the fire, few cinders were carried up. The combustion was very complete."—*American Annual of Scientific Discovery*, 1851, p. 163.

A Chemical Examination of the Metals and Alloys known to the Ancients. I. *History.* II. *Analyses of Ancient Alloys,* A. *Coins struck prior to the Christian Era.* B. *Analyses of Ancient Arms and Cutting Instruments.* C. *Table of Mean Composition of the Specimens analysed.* D. *Deductions.* By J. ARTHUR PHILLIPS, Esq., F.C.S.*

I. *History.*

Among the arts cultivated by mankind in the infancy of the world, metallurgy appears to have held a very prominent situation; for we read that Tubal Cain was an instructor of every artificer in brass and iron,† and consequently these, together with their uses, must have been well known to the antediluvians.

It is also probable that they were not the only metals in use at this remote period; for the extraction of iron from its ores, of itself indicates great metallurgical skill and experience, as from the refractory nature of the materials employed, a very intense heat and skilful manipulation must have been necessary to its production. From these considerations, we may infer that this metal could not have been discovered until the arts had attained a great degree of perfection, and long after the discovery of some others requiring less complicated apparatus and a lower temperature for their reduction. It would be quite impossible, after the lapse of so many ages, to trace the exact order in which the metals became known; but it appears natural to suppose that those which are found in a native state, were the first to attract the attention and exercise the ingenuity of mankind; and consequently, that gold, silver, and copper, were among the first with which the ancients became acquainted.‡ This, however, is but conjectural, as in the first mention of silver, Abraham is described as weighing unto Ephron, four hundred shekels of silver current money with the merchant, §

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* The above is an abstract of a memoir published in the valuable Quarterly Journal of the Chemical Society of London, for October 1851.

† Gen. iv. 22.

‡ It is true that iron is sometimes found in the native state, as large masses of meteoric origin have been occasionally met with. These, however, occur but seldom, and in quantities far too small to have supplied this metal for the uses of the arts.

§ Gen. xxiii. 16.

thus indicating that in those days, it was not only well known, but commonly used as a medium of exchange, for which purpose it was estimated by weight.

In the time of Moses, at least six metals were known, as in his direction for the purification of the spoils of the Midianites, he says, "Only the gold and silver, the brass, the iron, the tin, and the lead, every thing that may abide the fire, ye shall make it pass through the fire, and it shall be clean;"* thus shewing that the metallurgical arts had at that period attained considerable perfection, and that the metals were of frequent occurrence and constant employment. Of the processes practised in the early ages of the world, little can at present be known; but it would appear likely, from some passages in the sacred writings, as well as from the somewhat confused and obscure accounts of profane authors, that they differed but little from those which are employed at the present day.

That silver was at a very early period purified by means of lead, the following passages would seem to indicate: "The house of Israel is to me become dross: all they are brass, and tin, and iron, and lead, in the midst of the furnace; they are even the dross of silver."† And again, "the bellows are burned, the lead is consumed by the fire, the founder melteth in vain."‡ We also read of silver being purified in a furnace of earth. Strabo quotes Polybius as speaking of a silver ore which after being washed seven times, was melted with lead, and became pure silver.

That tin was not only well known, but also highly valued at the time of the Trojan war, we learn from Homer, who calls it *κασσιτερος*, and mentions it as forming part of the armour of Agamemnon§ and shield of Achilles,|| to make which, Vulcan is represented as throwing into the crucible brass unconquered, *κασσιτερος*, and honoured gold and silver.

Among the ancient Greeks and Romans, the workers of metal had attained a pitch of excellence, in some instances scarcely to be surpassed in the present day; but although many proofs of their skill have come down to us, in the form of coins, statues, and implements of war, yet their authors afford but scanty information relative to the methods employed in their production. This may be accounted for by the fact, that those who have written on the subject could have been but imperfectly acquainted with it; from the circumstance of the metals being generally found and extracted in mountainous countries, at a great distance from the large and populous cities in which the authors may be supposed to have usually resided, and who were, therefore, dependent for their facts on those who might be unable to enlighten them very fully on the subject.

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* *Numb. xxxi. 22.* † Ezek. xxii. 18. ‡ Jer. vi. 29. § Iliad, 2. || Iliad, 18.

Is it then to be wondered at, that our stock of information should be very limited, or that the ancient authors should treat rather of the uses of the metals, and the formation of alloys, than of their extraction from the ores?

The art of working the alloys of copper was cultivated in Rome at a very early period after the foundation of that city, as we read that King Numa, the immediate successor of Romulus, founded a fraternity of brass-founders, from which it may be inferred that the trade was even then in a flourishing condition.*

At the date in which Pliny wrote his Natural History of the World, the Romans had acquired a very extensive knowledge of the metals, and their uses; as we find him, in his thirty-third and thirty-fourth Books, not only describing gold, silver, brass, tin, iron, lead, antimony, mercury, and cadmia; but he gives us also the proportions in which these various metals should be mixed in order to form suitable alloys for casting, soldering, and brazing, and moreover describes with a great degree of accuracy, the medicinal and other properties of some of their oxides and salts, as well as the method of their preparation and the localities in which they were found. But his descriptions of the means used for the extraction of these metals from their ores, are not only imperfect, but also frequently very obscure. This arises both from the abrupt transitions which continually occur, and also from frequent allusions to methods and apparatus long since obsolete, and on which at the present time we have no means of acquiring any knowledge.

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* Pliny, xxxiv., 4.

In speaking of gold, Pliny says :* "In these parts of the world in which we live, gold mines are found, to say nothing of India, where the ants cast it up out of the ground, or that which the griffins gather in Scythia. The gold with us is procured in three ways; among the sands of some great rivers, such as the Tagus in Spain, the Po in Italy, Hebrus in Thrace, Pactolus in Asia, and the Indian Ganges, all of which yield gold. Neither is there any gold finer or more perfect, from being thoroughly polished by the rubbing and attrition which it meets with in the course of the streams of water. There is also another method of obtaining gold, viz., by digging it out of pits which are sunk for that purpose, or else in the caverns and breaches which occur by the fall of mountains." He also goes on to say, that the gold obtained by cleaving and opening mountains needs no trying or refining, as it is naturally fine and pure. In speaking of the value of gold, the same author remarks : †—"The reputation which it has acquired, is for the following reason, that it alone, of all things, loses nothing in the fire, but withstands its action without change. Indeed, the oftener it has been in the fire, the more refined and purer it becomes. One method of testing the quality of gold, is by the application of fire, of which it ought to take not only the colour, but, to a certain extent, the radiance also. This kind is called *obryzum*. This is another astonishing property of gold, that a fire made of light straw or chaff will quickly melt it; whilst, if it be thrown on the strongest fire of wood-charcoal, it will with difficulty yield to its intensity and melt. With respect to its purification, it should be melted with *lead*. The second property which causes gold to be so highly valued is, that it loses but little of its weight by use and attrition, whilst silver, lead, and copper, leave metallic stains on bodies which they touch, and soil the skin of those who handle them. Neither is there any metal which can be beaten out broader by the hammer, or divided more easily into parcels, as every ounce of it may be reduced into more than seven hundred and fifty leaves, each one of which being four fingers square. The other minerals, after their extraction, require the fire for their conversion into metal, but gold of which we now treat, is gold as soon as it is found." Again, "Neither rust nor canker alters the weight of gold, or affects in any way its quality. Salt and vinegar, though such active solvents, do not make the least impression on it."

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* Pliny xxxiii., 1.

† Pliny xxxiii., 3.

The above quotations go to shew, that many of the properties of gold were known at this period, and also that the methods of extracting it from the earth were similar to those employed at the present day. Pliny, however, gives us but little information relative to its metallurgic treatment, except that lead was employed in its purification, and also that when found in lumps it was of itself pure, and required no artificial refining. He also states, when speaking of the properties of mercury,* "So penetrating is this liquor, that there is no vessel but it will eat and pass through. It supports everything which may be thrown into it, unless it be gold only, which sinks to the bottom. It is besides, very useful for the purpose of refining gold; to effect which object, that metal mixed with cinders is placed in an earthen pot, and shaken with mercury, which rejects all the impurities mixed with it, but in return takes hold of the gold itself. To expel it from the gold, the mixture is poured on skins, which on being pressed, allow the mercury to pass through them in drops, whilst the gold remains in all its purity." The above process differs little from those in general use, for the purposes of amalgamation, at the present day, but in this case also, Pliny's description is very imperfect, inasmuch as the solid amalgam remaining on the skins would require the separation of the combined mercury before the gold could exist in the pure and fine state described. No mention is moreover made of any means of separating gold from silver, or in fact of their ever being found associated, except in an alloy called *electrum*,† said to be found in veins, and of which an artificial kind was made by mixing one part of silver and four parts of gold, and which appears to have been anciently in great request, as Homer describes the palace of king Menelaus as glittering with gold, electrum, silver, and ivory. This alloy, though sometimes made by the direct mixture of the two metals, was, doubtless, in most instances, a natural production, as many gold ores also contain a certain portion of silver, and the ancients being apparently ignorant of the method of separating them, and without any knowledge of the stronger acids,* might have been in the habit of occasionally adding a certain quantity of silver to specimens of gold which already contained a proportion of that metal, thereby converting it into electrum, in preference to allowing it to remain as impure gold.

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* Pliny xxxiii., 6.

† Pliny xxxiii., 4.

That silver was formerly, as at the present day, chiefly extracted from the ores of lead, we are distinctly informed by the author of the "Historia Naturalis," who adds, that those ores of silver which do not contain lead or an ore of lead, cannot be successfully worked without the addition of either one or the other. Tin and lead he seems to regard as only two varieties of the same metal, as he describes them under the title of white lead, and black, and states that the white lead, called in Latin *Plumbum candidum*, and by the Greeks, *Cassiteros*, was much more valuable, and commanded a higher price than the black variety.

His description of the Plumbum candidum, and the state in which it was found, leaves no doubt that this much-valued metal was tin, it being represented as occurring among sand, in the dried-up beds of rivers, and as only known from the other substances with which it was found associated by its dark colour and great weight.* "There is likewise found in the gold mines a kind of lead-ore which they call Elutia (stream tin). The water which is let into the mines washes, and carries down with it, certain little black stones, streaked and marked with white, and as heavy as the gold itself. It is gathered with it, and they remain together in the baskets in which the gold is collected. These are not separated from it until after melting in the furnace, when the fusion transforms them into white lead." Again: "You cannot solder together two pieces of black lead without white lead, neither can this be united to the other without the aid of oil." He also says of this metal: "Neither out of the white lead can any silver be extracted; whereas out of the black this is commonly done."

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* Nitric acid is first mentioned by Geber, who lived in the eighth century. He describes it under the name of "dissolving water," and prepared it by distilling in a retort one pound of sulphate of iron of Cyprus, half a pound of saltpetre, and a quarter of a pound of alum of Iameni. This process, although not economical, would certainly produce nitric acid, and to this, when obtained, he added sal-ammoniac, in order to give it the property of dissolving gold. Raymond Lully, who lived in the early part of the thirteenth century, employed the same process, except that he omitted the alum. Basil Valentine, who was born about the year 1400, describes a method of obtaining "Spirits of Nitre," by distilling nitrate of potash with powdered porcelain or clay, with which the potash entering into combination, the same result is obtained as by the former method. Basil Valentine is also the first who describes oil of vitriol, which he prepared by distilling sulphate of iron according to the method at present practised at *Nordhausen*, in Saxony.

In speaking of common lead, the same author says: "It is much used for conduit pipes, and for being hammered into thin plates," and then goes on to describe the mines of France, Spain, and Britain, which he states, when quite worked out and exhausted, become as productive as ever, and indeed even more so, if allowed to remain a short time without being worked, for which he accounts, by supposing the metal to be produced by the air, which has then free access into the mine. With regard to the state in which *Plumbum Nigrum* occurs, we are informed: "Black lead has a double origin; for it is either produced in a vein of its own without any other metal; or otherwise it is mingled with silver in the same mine, being mixed together in one stone of ore, and they are only separated by melting and refining in a furnace.† The first liquor that flows from the furnace is tin (*Stannum*), and the second silver. That part which remains behind is galena, the third element of the vein, which being again melted, after two parts of it are deducted, yields black lead."

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* "It is generally considered that the Greeks obtained their tin by means of the Phœnicians from the Scilly Islands or Cornwall, but there is no direct proof of this; and it appears probable, from the Sanskrit derivation of the Greek word (kassiteros, from kastirâ), that the Greeks originally obtained their tin from India. The Islands Cassiterides, however, the position of which was unknown to Herodotus (III., 115), are supposed to be the Scilly Islands, or the peninsula of Cornwall, though their position is not exactly defined by Strabo (III., 175). Still there can be little doubt that the Cassiterides, to which the Phœnicians from Gades (Cadiz) went for tin, and the Romans afterwards traded for the same commodity, were on the south-western angle of Great Britain."—Pen. Cyc. Art. 'Hindustan.'

† Hist. Nat. xxxiv., 16.

The above passage is very obscure: tin, lead, and silver are not frequently found together in the same stone, and were they thus to occur, the tin certainly would not be the first to flow out of the furnace.

Professor John Phillips, in his excellent paper on "Ancient Metallurgy and Mining in Brigantia,"* seems to be of opinion that the method here described might have had some resemblance to that invented and patented by H. L. Pattinson, Esq. This, however, appears less probable when we consider that if, in Pattinson's process, the rich lead were run off, instead of dipping out the poor in the form of crystals, the metal thus obtained being but sparingly mixed with silver, would not have been called stannum, by which term an alloy of tin and lead is frequently expressed. It, therefore, does not seem impossible that the operation referred to was simply cupellation, in which process the "*abstrichs*" and first litharge flowing from the furnace is much more impure than that subsequently obtained, and therefore, when reduced, would yield a harder lead, not unlike pewter or *Stannum*. The silver thus obtained would of course remain on the cupel, whilst the litharge which flowed from the furnace after it got into steady action, together with that absorbed by the cupel itself, would, on being melted with a reducing agent, yield pure, or nearly pure lead. I think, therefore, the author intends to convey the idea that three parts of litharge and "*debris de coupelle*" yield only one part of lead.

That cupellation has long been employed for the extraction of silver from lead may be inferred from the works of Agricola,† who in his "De Re Metallica," describes and gives drawings of the furnaces used in his time for that purpose, and which exactly correspond in every respect with the old German cupels in use at the present day in many parts of the Continent.

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* Proceedings of the Yorkshire Philosophical Society for March 1848.

† Born A.D. 1494.

The Greeks and Romans have left no treatises relative to chemistry or metallurgy; but it is scarcely reasonable to suppose, that had the method of refining lead by crystallization been known to them, it should either have been lost or fallen into disuse, as its advantages are too obvious not to have been evident to the rudest operators. Another argument against the opinion of Pliny having referred to this method, is the fact that rich lead, and not pure silver as described by him, is obtained by the crystallizing process, and if this method were ever known, it must evidently have fallen into disuse before the time of Agricola, who makes no mention of any knowledge on the subject, but gives the old German furnace as that ordinarily employed for the extraction of silver, and which, from the circumstance of its having remained unchanged in every respect since the days of Agricola, may be inferred to have existed in the same form long prior to that time; and to have been probably not only used by the Greeks and Romans, but possibly even at a much earlier date.

Of all the metals employed by the ancients for the manufacture of objects of luxury, as well as for those adapted to the every day usages of life, copper and its alloys were the most common; as by far the greater portion of the coins, tools, and implements of war, which are occasionally brought to light, are composed of some modification of either bronze or brass; and consequently, the making of these alloys, and their adaptation to the various wants of mankind, must have formed a very important branch of the manufactures among the Greeks and Romans. Accordingly, the author of the "Natural History of the World," after describing the properties of this metal, and stating the localities in which that of the best quality was found, gives the composition and proportions employed in the various alloys then common in Rome, and informs us to what uses they were severally applied. He also states that copper was first found in the island of Cyprus, from whence two distinct kinds were exported:[*] one called *Coronarium*, which when reduced into thin leaves and coloured with the gall of an ox, had a golden colour, and was employed for making coronets and tinsel ornaments for actors, from which circumstance it derived its appellation. Another variety, which was named *Regulaire*, is not particularly described, except that, like the former, it would stand hammering, and might be thus made to take any required form. The brass (copper) of the next best quality came from Campania, where it was the custom to add eight parts of lead to every 100 pounds of copper. It is also mentioned, that in France it was usual to melt copper among red-hot stones, for the purpose of obtaining a steady heat, as a quick fire was found to blacken the metal and render it brittle. He moreover informs us that the process was completed in one operation, but states that the quality would be improved by more frequent melting: moreover, it may not be amiss, to state also, that all kinds of brass melt best in the coldest weather. For statues and tables, brass is worked in the following manner:—first the ore, or stone, as it comes out of the mine is melted, and as soon as this is done, they add to it a third part of scrap brass, consisting of broken pieces of vessels that have been used; for it is time and use alone that bring brass to perfection, it is the rubbing which conquers the natural harshness of the metal. They then mix twelve pounds and a half of tin to every hundred pounds weight of the aforesaid melted ore. The softest alloy is called *Formall*, in which are incorporated a tenth of black lead, and one-twentieth part of argentine lead; it is this mixture which best takes the colour called grecanic. The last alloy is that which is called *Ollaria*, or pot brass, as it takes its name from the vessels for which it is mostly employed, and this is made by tempering every hundred pounds weight of brass with three or four pounds weight of argentine lead or tin."[†]

The alloys above described, are merely modifications of bell metal or bronze; but it is not improbable that the ancients were acquainted with zinc brass long before this period. Aristotle tells us that the Mosynæci, a people who inhabited a country not far from the Euxine Sea, were said to make their copper of a splendid white colour, not by the addition of tin, but by mixing and cementing it with an earth found in that country.* We are also informed by Strabo, that in the neighbourhood of Andêra, a city of Phrygia, a remarkable kind of stone was met with, which being calcined became iron, and on being fluxed with a certain kind of earth, yielded drops of a silvery-looking metal, which when mixed with copper, formed an alloy called *Aurichalcum*.†

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[*] Pliny, xxxiv., 8.

[†] Ib. xxxiv., 9.

Sextus Pompeius Festus, who abridged a work of Verrius Flaccus, a grammarian of considerable note in the time of Augustus, mentions cadmia, which he defines as an earth thrown upon copper, in order to convert it into aurichalcum.‡

On this subject Pliny affords us but little information, merely stating where cadmia was found, and naming some of its medicinal properties, but he seems to have regarded it rather as an earth which gave a yellow colour to copper, than as the ore of a distinct metal, zinc being in no instance mentioned by him, although he speaks of a kind of brass which was manufactured in the island of Cyprus from copper and cadmia.

If the foregoing quotations were not sufficient to shew that the ancients were acquainted with the art of making zinc brass, the fact has been fully proved by the analyses given in a subsequent part of this paper, by consulting which, zinc will be found to occur some time previous to the Christian era, although at what precise period it would be impossible to determine, without multiplying experiments to an unreasonable extent. That metallic zinc, however, was known to the ancients, there is no evidence to prove, since the metal mentioned by Strabo as given out in drops from a certain stone when heated, could scarcely have been zinc, which would, to a great extent, have been volatilized if treated in the way described, and we may therefore suppose, that if the stone referred to by him was an ore of zinc, it might also have contained some other metal, such as lead, with which it is often found associated, and which would produce the appearance in question. Ambrose, Bishop of Milan, describes the transformation of copper into aurichalcum as being effected by means of a drug,* and not by the addition of another metal, from which we may infer he was unacquainted with the metallic nature of the material employed, although from his calling it a drug, he was perhaps aware of its medicinal properties.

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* Arist. de Mirab. Op. ii., 721.

† Strabo, Geo. lxiii.

‡ "Cadmia terra quæ in æs conjicitur ut fiat aurichalcum."—*Fes. de Ver.* seq.

A similar description of the manufacture of brass is given by Primasius, Bishop of Andrumetum, in Africa, in the sixth century, and by Isidorus, Bishop of Seville, in the seventh. Agricola, who wrote in the sixteenth century, was also evidently ignorant that cadmia contained zinc, of which we have no authentic account until we find it mentioned by Paracelsus; and from which it is evident, that although the manufacture of zinc brass is of great antiquity, the extraction of the metal itself is comparatively a modern discovery.

Iron, the last of the six metals known to the ancients, was not, in the earliest times, very extensively employed, as the primitive heroes are described as being armed with weapons of brass.

Pisander is represented as attacking Agamemnon with a pole-axe, of which Homer says:—

"An olive's cloudy grain the handle made,
Distinct with studs, and brazen was the blade." †

Plutarch informs us that when Cimon, the son of Miltiades, conveyed the bones of Theseus from the island of Scyros to Athens, he found interred with him a bronze sword and a spear head of the same metal. ‡

Although generally used, however, brass was not universally employed for the manufacture of arms, as the celebrated robber, Periphetes, slain by Theseus, was named Korunetes (Κορυνήτης) from using an iron club, and Arëithous is described by the author of the Iliad as:— §

"Great Arëithous, known from shore to shore,
By the huge knotted *iron* mace he bore;
No lance he shook, nor bent the twanging bow;
But broke with this the battle of the foe."

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* Amb. in Apoc., ci.

† Iliad, v., 612, Pope's Trans.

‡ Theseo.

§ Iliad, v., 136, Pope's Trans.

In the days of Herodotus iron must have already come into general use, as when his interpreter reads to him an inscription on one of the Egyptian Pyramids relative to the amount of money expended on radishes, onions, and garlic for the workmen employed in its construction, he makes the reflection, that if this were true, how much more must have been paid for *iron tools* and bread ![*]

It would again seem almost incredible that these stupendous structures could themselves have been erected without the aid of steel, both for quarrying and shaping the stone, as well as for cutting the hieroglyphics so common in the earliest specimens of Egyptian architecture. If then, we allow that iron tools were employed in building these monuments, we must suppose this metal to have been in common use during the reign of the shepherd kings who conquered Egypt and occupied the throne of the Pharaohs during some part of the interval which elapsed between the birth of Abraham and the captivity of Joseph.[†]

In speaking of iron, Pliny says:[‡] "After copper comes iron, both the most useful and most fatal instrument of life. With iron man delves the earth, plants trees, prunes his orchard, trims his vines, cutting off the older branches, and thereby throwing more vigour into the grapes : by its aid man builds houses, cuts stone, and prepares a thousand other implements; but by it war, atrocity, and villany is effected and rendered common." He also describes iron as occurring in almost every part of the known world, but particularly in the Island of Elba, where the colour of the earth indicated the presence of the ore.

We are moreover informed that the ores of iron should be treated like those of copper, in order to extract the metal, and that it was a disputed point in Cappadocia, whether the principle of iron was aqueous or earthy in its nature, as the water of a certain river of that country when thrown on the earth, produced iron, precisely similar to that obtained from a furnace. He then goes on to say, that there are two distinct kinds of forges, as some produce steel (*nucleus ferri*), which is best adapted for cutting-instruments; whilst others shape it into instruments of common use, such as hammers and anvils; but that seasoning is the most important and delicate part of the operation. "It is a remarkable fact that, in the treatment of this mineral, the metal in melting is at first as liquid as the most limpid water, but becomes spongy in getting cold." *

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[*] Herod. Euterpe, ii., 125.

[†] Russel's Egypt, 89.

[‡] Pliny, xxxiii., 14.

From the extracts already quoted, it will be seen that the information which has come down to us relative to the metallurgy of the early ages, is both vague and, to some extent, uncertain; as those who describe the materials and methods employed, have themselves acquired their information from others, and were therefore more subject to commit errors, than if practically acquainted with the subject of which they treated. This circumstance has induced me to believe that a careful analytical examination of such productions of the early metallurgists, as have been discovered in different localities, would not be without interest, and I have therefore undertaken the following series of analyses.

II. *Analyses of Ancient Alloys.*

A.

Coins struck prior to the Christian Era.

Commerce in remote antiquity, was carried on by means of the mere exchange of commodities; and it is remarkable, that throughout the more ancient books of Scripture, as well as in the poems of Homer, no passage occurs from which it can be inferred, that stamped money was then in circulation, although mention is repeatedly made of purchases being effected through the medium of the metals, which, for that purpose, were estimated by the balance. Herodotus (I, 94) speaks of the Lydians as the first who coined gold and silver into money. The Parian Chronicle, however, ascribes the origin of coined money to the Æginetans under Phidon, King of Argos, who reigned 895 years before the Christian era.† Ælian, in his "Various History," corroborates this statement, and the most competent numismatic authorities agree in considering the coins of Ægina as the most ancient specimens of stamped money which have come down to us. These are of silver, and bear on the upper side the figure of a turtle, and on the reverse an indented mark, as if the metal at the time of striking had been held on a puncheon, which, from the force of the blow, appears to have left a deep impression.

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* Iron in Pliny's time was doubtless made by the direct, or Catalan process, and the spongy appearance above described must have arisen, not from its cooling, as he seems to suppose, but from combustion of the combined carbon, and the consequent conversion of the compound into malleable iron.

† This chronicle, as it is called, consists of a series of Greek inscriptions cut in Parian marble. It was discovered in the beginning of the seventeenth century in the island of Pharos, one of the Cyclades, and was bought and *brought to England* by the celebrated Thomas, Earl of Arundel. It is proved

The coins of Lydia would seem to come next in point of antiquity, and after them, the early Darics of the Persian kings, which occur in both silver and gold. Pinkerton observes—"The first Grecian copper coins with which we are acquainted, were those of Gelo, King of Syracuse, about 490 years before the birth of Christ. These were called *Chalci*, or pieces of brass; others of a smaller size were denominated *Lepta*, or *Kerma*, from being change for the poor." He is also of opinion, that the Greeks had no gold coinage before the time of Philip of Macedon, and that Athens had no gold money before the Peloponnesian war.*

The first Roman coinage was of brass, and is said to have taken place under Servius Tullius, about five centuries before the Christian era, and seems to have been confined to the *as* or *æs*, which on one side bore the two-faced head of Janus, and on the other the prow of a ship, a symbol always attending Janus, because he arrived in Italy by sea.

Varro,† however, informs us, that the first Roman coins bore the stamp of a bull, ram, or some other cattle, and it is therefore probable that the *As* with the head of Janus, was not the very first design issued from the Roman mint.

However this may be, soon after the first coinage of brass, the parts of the *As* of a value proportionate to their weight were also produced.‡ The *Semis*, or half *As*, marked S., had commonly the head of Jupiter laureated; the *Triens*, or third, marked 0000, as being originally four ounces, had the head of Minerva; the *Quadrans*, or quarter, 000, the head of Hercules, wrapt in a lion's skin; the *Sextans*, or sixth, 00, that of Mercury with a cap and wings; and finally the *Unica*, marked 0, had the head of Rome.

All the above coins were cast, as were also those of the Etruscans from whom the Romans learnt the art of moulding their money; and that several were usually obtained at each melting is evident from the fact that three or four have occasionally been found joined by runners of the metal of which they are made. Most of the specimens also retain the marks produced, by cutting off these threads, as likewise the lines indicating the division of the two parts of which the mould was composed.

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by internal evidence that this chronicle was engraved 264 years before the birth of Christ, most likely for Athens.

* Pinkerton on Medals, 1, 77.

† *Varro de Re. Rust. I, 2.*

‡ Pinkerton on Medals, 1, 101.

Roman As *or* Æs. B.C. 500.*

Weight, 4150 grains. Specific gravity, 8·59. Obverse: The head of Janus. Reverse: A ship.

The metal of which it was composed, presented an iron-grey appearance when broken, but if cut, the peculiar hue of copper was immediately perceived. Large cavities were also observed in the substance of the alloy, occasioned by bubbles of air, which being shut up in the mould, had caused numerous holes in the casting. For analysis *vide* Table.

Semis. Same date as the foregoing.

This coin bears on one side the head of Jupiter laureated, and on the other the letter S. Its weight, although not quite perfect, was 1997 grains. Specific gravity, 8·64. For analysis *vide* Table.

Quadrans.

This is supposed to be of the same date as the preceding, being of similar rude workmanship and brittle metal. The specimen examined bore on one side the head of Hercules, and on the other a design in which the marks 000 were conspicuous. Its weight was 970 grains; its specific gravity, 8·58. For analysis *vide* Table.

Hiero I. B.C. 478.

Hiero I. succeeded his brother Gelo as King of Syracuse, 478 years before our era, and reigned eleven years.

The coin examined was of a yellow colour, and the metal bright and close in its grain, being extremely hard and difficult to cut. Specific gravity, 8·72. For analysis *vide* Table.

Alexander the Great. About B.C. 335.

This coin weighed 108 grains, and the metal of which it was composed had a specific gravity of 8·69. For analysis *vide* Table.

Philippus III.

Natural son of Philip II. and half brother of Alexander, whom he succeeded as King of Macedonia, in the year 323 before our era. The coin examined weighed 83·3 grains, and bore on one side a head, and on the other a man on horseback. This metal resembled that of which the coin of Alexander was composed, and had a specific gravity = 8·71. For analysis *vide* Table.

Philippus V. B.C. 200.

Weight about 164 grains. Specific gravity = 8·59. For analysis *vide* Table.

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* M. Le Normand considers the Roman As of this type, to have been coined about B.C. 385. Other authors, however, regard the date above given, as being more correct.

Copper Coin of Athens.

Weight = 89·5 grs. Specific gravity = 8·61. Obverse: Head of Minerva. Reverse: A naked figure, represented in the act of hurling a thunderbolt. Metal very hard. For analysis *vide* Table.

Egyptian. Ptolemy IX. About B.C. 70.

Auletes (The Flute-player).

This coin was made of a very brittle metal, and weighed 337 grs. On one side it bore the impression of a bearded head, and on the other an eagle holding a thunderbolt. Specific gravity = 8·81. For analysis *vide* Table.

Pompey. First Brass. B.C. 53.

Weight, 309 grs. Specific gravity, 8·70. Obverse: Head of Janus. Reverse: Prow of a ship.

This coin was evidently cast, and the metal is very hard and brittle, resembling in this respect the alloy employed in the original *as*, before its reduction in weight. For analysis *vide* Table.

Coin of the Atilia Family. B.C. 45.

This coin bears, on one side, the head of Janus; and on the other the prow of a ship, with the word *Roma* beneath it. The metal is extremely hard and brittle, but has been struck with a die. Weight = 466 grs. Specific gravity = 9·02. For analysis *vide* Table.

Julius and Augustus. About B.C. 42.

Weight, 342 grs. Specific gravity, 8·64. For analysis *vide* Table.

Augustus and Agrippa. B.C. 30.

Conquest of Egypt.

Weight, 238 grs. Specific gravity = 8·65.

This coin bears two heads on one side; and on the other a crocodile, with *Col: Nem.* Metal very hard and brittle. For analysis *vide* Table.

Large Brass of the Cassia Family. About B.C. 20.

Weight 365 grs. Specific gravity = 8·52.

Metal of a yellow colour, and softer than any of the foregoing. For analysis *vide* Table.

B.

Analyses of Ancient Arms and Cutting Instruments.

It would be impossible to determine the dates of these relics of former times with the same accuracy with which we may ascertain the ages of coins; and I shall therefore merely give the weight and dimensions of the various specimens which have been examined, and endeavour to adduce such evidence as may shew their great antiquity, without attempting to specify the precise dates at which they were employed. The ancient authors who have written on this subject, all agree that brass was used for the manufacture of arms before the discovery of iron. Lucretius says*—

> "Arma antiqua manus, ungues, dentesque fuerunt,
> Et lapides, et item silvarum fragmina rami,
> Et flammæ, atque ignes, postquam sunt cognita primum
> Posterius ferri vis est ærisque reperta
> Sed prius æris erat quam ferri cognitus usus."

Hesiod also informs us that, "In remote ages, the earth was worked by brass, because iron had not been discovered." The Etrurians were acquainted with the use of copper, and appear to have used it for the purposes of agriculture at a very early period, as when the boundaries of their city were marked out, it was done with a ploughshare of bronze.† Numerous other authorities might, if necessary, be quoted in support of the above statements; but the opening of divers Scandinavian tumuli, of very remote antiquity, in Denmark, fully establishes the accuracy of these accounts. From these barrows have been collected specimens of swords, daggers, knives, and implements of industry, since preserved and arranged in the Museum of Copenhagen, and among them are instruments of flint, resembling in their shapes, our wedges, axes, chisels, hammers, and knives; which we may infer, from their rude workmanship, as well as from the materials of which they are formed, to have been the first description of edge tools used by mankind for the several purposes for which they were adapted. Specimens of swords, daggers, and knives were also found, of which the blades are made of gold, whilst the cutting edges only are of iron. Some of these objects are composed principally of copper with edges of iron; and in the whole of them, the profuse application of copper and gold, in comparison with the parsimony evident in the expenditure of iron, seems to prove that at that early, though unknown period, both gold and copper were more plentiful, and less highly valued than iron, among the now-forgotten people who manufactured these implements.‡

Although we have the best evidence for believing that copper and bronze were employed for the purpose of making cutting instruments before the discovery of iron, it would be more difficult to ascertain at what date and among what nation this metal first came into general use. That it was known at a very early period we learn from various passages in the Books of Moses; and that it was used in the days of Job (about B. C. 1400) for the manufacture of arms, is evident from the following passage:—"He shall flee from the iron weapon, and the bow of steel shall strike him through.§

It is nevertheless probable that bronze might have been in common use long after the discovery of the harder metal, as the preparation of iron must have been a very tedious and expensive operation, to a people having but a scanty knowledge of the metallurgic arts, and we accordingly find a kind of compromise between its known utility and high commercial value in the case above quoted, in which the cutting edge alone is made of steel. At the present day, a valuable discovery made in any part of the world would speedily become known and appreciated throughout its whole extent, but at the remote time in which iron was first reduced from its ore, so little communication existed between the various nations, that that which might be well known and highly valued by the inhabitants of one country or state, might be quite unheard of in another, and consequently the uses of this metal may for a long time have been limited to a few districts where accident, or the smelting of some other mineral, had first revealed its presence. In the earliest ages of recorded history, when the world was divided into numerous petty states and principalities, the constant feuds, which were the principal occupation of mankind, would certainly cause a demand for arms and weapons of defence. Such a state of things must, however, operate most unfavourably on the cultivation of the arts; and it is not reasonable to suppose that a conquering army on entering a foreign territory would have sufficient leisure to acquire the arts of the conquered nation, and consequently, although they might find the arms of their enemies superior to their own, they would still be ignorant of the means by which they were manufactured; and thus the secret would remain for a long period in the possession of its first discoverers. At what precise epoch weapons of iron came into general use among the Romans, we have not sufficient information to decide, but in the time of Augustus* iron mines were worked to a considerable extent in the Noric Alps (now Illyria), and from them iron of the first quality was obtained—this was used for making the best weapons, and hence "Noricus ensis," was as much synonymous for a good sword, as a Toledo, or Andrea Ferrara blade in more modern times.† In this sense it is used by Horace, Book i., ode xvi., v. 9. At the time in which Pliny wrote his "Historia Naturalis," iron was almost universally employed, not only for the blades of swords, but also for the manufacture of the different cutting instruments used for the purposes of daily life, as he both describes the metal and the means of forging it, and also refers to the difficulty of tempering steel in order to give it the requisite degree of hardness.

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* Lib. i., 1282.

† Macrob. Saturn. v., 19.

‡ Jacob on the Precious Metals, I, 3.

§ Job xx., 24.

From these considerations, it is evident that the various weapons of bronze must be of great antiquity, since iron was in common use prior to the Christian era, and I have therefore placed the analyses of these instruments, in a part of the series which corresponds to that period, notwithstanding that in all probability some of them may belong to a much earlier date.

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* B. C. 30.

† Jacob on the Precious Metals, 1, 88.

Sword-Blade (Fig. 1.)

Found under Chertsey Bridge, Thames. Weight, 1 lb.; length, 17 inches; breadth at widest part, 1¾ inch; breadth where broken, 1⅛ inch. For analysis *vide* Table.

Broken Sword-Blade (Fig. 2.)

Found in Ireland. Weight, 4 oz.; length, 8 inches; breadth at the hilt, 1¾ inch; breadth where broken, 1 inch. For analysis *vide* Table.

Fragment of a Sword-Blade (Fig. 3.)

Found in Ireland. Weight, 6 oz.; length, 8½ inches; width at the broadest part, 1¾ inch; at the narrowest, 1¼ inch. For analysis *vide* Table.

Broken Spear Head (Fig. 4.)

Found in Ireland. Weight 11½ oz. For analysis *vide* Table.

Celt (Fig. 5.)

Found in Ireland. Weight about 10 oz. For analysis *vide* Table.

Celt (Fig. 6.)

Weight, about 1 lb. For analysis *vide* Table.

Celt (Fig. 7.)

Weight, 4 oz. For analysis *vide* Table.

Celt (Fig. 8.)

Weight, about 5¾ oz. Specific gravity = 8·09. For analysis *vide* Table.

C.

Coins struck since the Commencement of the Christian Era.

Large Brass of Nero. A.D. 60.

Reverse: Rome seated.

Weight, 435 grs. Specific gravity = 8·59. Metal of a bright yellow colour. For analysis *vide* Table.

Titus. A.D. 79.

Weight, 178 grs. Specific gravity = 8·5. Metal yellow and soft. For analysis *vide* Table.

Hadrian. A. D. 120.

Fortunæ reduci.

Weight = 365 grs. Specific gravity = 8·30. This coin is finely patinated, and the metal of a fine yellow colour. For analysis *vide* Table.

Faustina, Jun. A.D. 165.

Pietas.

Weight = 362 grs. Specific gravity = 8·83. Coin without patina. Metal of a whitish colour, and very brittle. For analysis *vide* Table.

Greek Imperial Samosata. About A.D. 212.

Reverse: The city seated.

Weight = 274 grs. Specific gravity = 8·53. Metal of a greyish colour; very coarse and brittle. No patina. For analysis *vide* Table.

Small Brass of the time of the Thirty Tyrants. About A.D. 260.

Victorinus, Sen. (No. 1.)

Providentia Aug.

Weight = 37·7 grs. Specific gravity = 8·77. Metal rather hard, and not patinated. For analysis *vide* Table.

Victorinus, Sen. (No. 2.)

Salus Aug.

Weight = 37·6 grs. Specific gravity = 8·73. Coin not patinated. For analysis *vide* Table.

Tetrius, Sen. A.D. 267. (No. 1.)

Weight = 37·3 grs. For analysis *vide* Table.

Tetrius, Sen. A.D. 268. (No. 2.)

Weight = 45·25 grs. For analysis *vide* Table.

Claudius Gothicus. A.D. 268. (No. 1.)

Spes publica.

Weight = 52·2 grs. Specific gravity = 8·81. Coin thinly covered with red patina. Metal rather hard. For analysis *vide* Table.

Claudius Gothicus. A.D. 268. (No. 2.)

Juno Regina.

Weight = 58·3 grs. Specific gravity = 8·71. For analysis *vide* Table.

Tacitus. A.D. 275. (No. 1.)

Libertas Aug.

Weight = 62·3 grs. Specific gravity = 8·72. For analysis *vide* Table.

Tacitus. (No. 2.)

Pax publica.

Weight = 49·5 grs. Specific gravity = 8·70. For analysis *vide* Table.

Probus. (No. 1.)

Succeeded Tacitus, who reigned only six months.

Clementia Temp.

Weight of coin, 52·2 grs. Specific gravity = 8·72. For analysis *vide* Table.

Probus. (No. 2.)

Mars Victor.

Weight = 49 grs. Specific gravity = 8·74. For analysis *vide* Table.

TABLE C.—*Shewing the Mean Compositions of the Specimens Analysed.*

	Date.		Copper.	Tin.	Lead.	Iron.	Zinc.	Silver.	Sulphur.	Nickel.	Cobalt.
	B.C.	A.D.									
ÆS	500	...	69·69	7·16	21·82	·47	...	...	trace	trace	·57
Semis	500	...	62·04	7·66	29·32	·18	...	...	trace	·19	·23
Quadrans	500	...	72·22	7·17	19·56	·40	...	...	trace	·20	·28
Hiero I.	470	...	94·15	5·49	...	·32	...	...	...	...	...
Alexander the Great	335	...	86·77	12·99	...	...	...	...	·06	...	...
Philippus III.	323	...	90·27	9·43	...	...	...	...	...	...	...
Philippus V.	200	...	85·15	11·12	2·85	·42	...	...	trace	...	...
Copper coin of Athens	?	...	88·34	9·95	·63	·26	...	...	...	trace	trace
Egyptian, Ptolemy IX.	70	...	84·21	15·64	...	trace	...	...	trace	...	trace
Pompey, First Brass	53	...	74·17	8·47	16·15	·29	..	...	...	...	...
Coin of the Atilia Family	45	...	68·69	4·86	25·43	·11	...	...	...	trace	trace
Julius and Augustus	42	...	79·13	8·00	12·81	trace	...	...	trace	...	...
Augustus and Agrippa	30	...	78·45	12·96	8·62	trace	...	...	trace	...	...
Large Brass of the Cassia Family	20	...	82·26	...	...	·35	17·31	...	trace	...	...
Sword-blade (Fig. 1.)	...	...	89·69	9·58	...	·33	...	...	trace	...	...
Broken sword-blade (Fig. 2.)	...	...	85·62	10·02	...	·44	...	...	...	...	...
Fragment of a sword-blade (Fig. 3.)	...	...	91·79	8·17	...	trace	...	...	trace	..	...
Broken spear-head (Fig. 4.)	...	..	99·71	...	...	...	...	...	·28	...	...
Celt (Fig. 5.)	...	...	90·68	7·43	1·28	trace	...	...	trace	...	...
Celt (Fig. 6.)	...	...	90·18	9·81	...	trace	...	...	...	...	...
Celt (Fig. 7.)	...	...	89·33	9·19	...	·33	...	...	·24	...	...
Celt (Fig. 8.)	...	...	83·61	10·79	3·20	·58	...	...	...	trace	·34
Large Brass of Nero	...	60	81·07	1·05	...	...	17·81	...	...	...	...
Titus	...	79	83·04	...	...	·50	15·84	...	...	...	...
Hadrian	...	120	85·67	1·14	1·73	·74	10·85	...	...	...	...
Faustina, Jun.	...	165	79·14	4·97	9·18	·23	6·27	...	...	...	...
Greek Imperial Samosata	...	212	70·91	6·75	21·96	trace	...	...	...	...	...
Victorinus, Sen. (No. 1.)	...	262	95·37	·99	trace	trace	...	1·60	...	...	...
Victorinus, Sen. (No. 2.)	...	262	97·13	·10	trace	1·01	...	1·76	...	...	...
Tetrius, Sen. (No. 1.)	...	267	98·50	·37	trace	·46	...	·76	...	...	...
Tetrius, Sen. (No. 2.)	...	268	98·00	·51	...	·05	...	1·15	...	...	...
Claudius Gothicus (No. 1.)	...	268	81·60	7·41	8·11	...	...	1·86	...	...	...
Claudius Gothicus (No. 2.)	...		84·70	3·01	2·67	·31	trace	7·93	...	...	...
Tacitus (No. 1.)	...	275	86·08	3·63	4·87	...	...	4·42	...	...	...
Tacitus (No. 2.)	...		91·46	...	...	2·31	...	5·92	...	...	...
Probus (No. 1.)	...	275	90·68	2·00	2·33	·61	1·39	2·24	...	...	...

D.

Deductions.

We learn from the foregoing analyses that the metals entering into the composition of the brass of the earliest ages were copper, tin, and lead, although the latter seldom occurs in any considerable quantity, except in the oldest specimens, and in many even of these, particularly in the early Macedonian coins, it is entirely wanting. The iron, cobalt, and nickel, together with traces of sulphur, which sometime occur, are evidently too small in quantity to have been intentionally added to the mixture, and consequently their presence must be rather ascribed to the localities from which the ancients drew their supply of ores, and the imperfect methods employed for their reduction, than to any design on the part of the artists. The cutting instruments which have been examined, are uniformly composed of copper and tin, with the occasional admixture of a small quantity of lead, which was probably added for the purpose of communicating a certain degree of toughness to the alloy, and it is also remarkable that the proportion of tin to that of copper, both in the celts and sword-blades, is very nearly as one to ten.

Zinc first makes its appearance a short time previous to the Christian era, and is continued in all the subsequent coins, although occasionally associated with lead and tin, until it almost entirely disappears in the small brass of the period of the Thirty Tyrants, when its place is supplied by a quantity of silver, varying from 0·76 to nearly 8 per cent., and which may perhaps have been intentionally added for the purpose of increasing the value of the metal.

In speaking of these coins, Pinkerton remarks:—"It may be proper to observe, before leaving this part of my subject, that the metal used in the Parts of the Assarion, or in the small brass coins, is, as may be supposed, very little attended to by the ancients. In those of the first emperors, yellow brass is sometimes employed, but it is always of a refuse, or bad kind; as in the Semis of Nero, for instance, GENIO AVGVSTI. But copper is the general metal used in parts of the As, from the earliest times down to the latest; and if sometimes brass be employed, it is never such as appears in the Sestertii and Dupondiarii, which is very fine and beautiful; but only the refuse. Yellow brass of the right sort seems to have totally ceased in the Roman coinage, with the Sestertius, under Gallienus; though a few small coins of very bad metal, of that hue appear so late as Julian II."*

On referring to the table of analyses, we shall, however, perceive, that although the results obtained seem to confirm the assertions made relative to yellow brass, in the above quotation, yet that in no one instance, has a coin been found to consist of copper alone; and the only case in which this metal proved to be unalloyed, was in the spear-head, Fig. 4, found in Ireland. The largest proportion of lead occurs in the ancient Roman As, and its parts, in which it was probably employed for the purpose of rendering the alloy of which they consist easily fusible; for these coins being originally cast and not stamped like other money, a metal melting at a low temperature would materially facilitate this operation.

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* Vol. i., 126.

The later coins, containing a large proportion of tin, seem to have been struck whilst the metal was still warm, as it would be impossible to obtain such sharp impressions as they usually bear, by the force of any blow applied on a metal so very hard and brittle, at ordinary temperatures.

Pinkerton states, that in the Roman mint, the alloy was first cast into the form of bullets, and that these were afterwards flattened and struck by the die, until an impression of sufficient depth was obtained. The appearance of many both of the Greek and Roman coins, indicates that the form of the blank pieces was spherical, but the metal of these very coins, is frequently so brittle, that they may easily be broken by a blow from the hammer, and could not have received their present form without being previously heated and struck whilst the metal was in a pasty state. That this was the method actually employed, is rendered very probable from some of the devices on the coins themselves, particularly on a Denarius of the Carisia family, bearing on the obverse, the head of Moneta, with name; and on the reverse, the implements used by the Romans in their coinage, viz., two dies, with the hammer and pincers; which is doubtless a correct representation of the apparatus employed in the Roman mint.* From the presence of the pincers in this design, it is almost certain that the metal was struck hot, as the blank could otherwise be more conveniently placed on the die by the hand, than through the intervention of tongs, which would rather embarrass than facilitate the operation.

With respect to the furnaces employed by the ancients, little information can be obtained, as these arts were formerly either held as secrets by a few individuals, who made a mystery of their operations, or they were too much despised by ancient authors, to afford them a subject for their writings; and we are consequently more indebted for our scanty knowledge of ancient metallurgy to the vestiges of primitive foundries, which have occasionally been brought to light in various parts of the world, than to any accounts which may have been transmitted to us from those remote times.

The first method of smelting ores, doubtless consisted in placing the mineral in heaps, together with several successive layers of wood, which being kindled, first roasted, and then reduced a portion of the material with which it was mixed. In Macedonia, where lead mines were worked in the time of Philip, the father of Alexander, large heaps of slag are found so far above the level of the rivers of the country, that the furnaces in which they were produced must have been worked either by bellows moved by human labour, or by the force of the prevailing winds alone.* We are also told, that the Peruvians were in the habit of melting their ores by the simple application of fire, or when they were of a very refractory nature, by means of furnaces so constructed on high ground as to yield a draught without the aid of bellows, a machine with which they were totally unacquainted.†

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* Till on Coins, 7.

The boles of Derbyshire, many of which from the pigs of Roman lead found in their vicinity, may be presumed to be of great antiquity, were worked in nearly a similar manner, and continued to be thus carried on during several centuries, as this method of smelting was, according to Childrey, not quite extinct in the seventeenth century, who, in speaking of the Peak, says:—"The lead-stones in the Peak, lie but just within the ground, next to the upper crust of the earth. They melt the lead on the top of the hills that lie open to the west wind; making their fires to melt it as soon as the west wind begins to blow, which wind, by long experience, they find to hold longest of all others. But for what reason I know not, since I should think lead were the easiest of all metals to melt, they make their fires extraordinary great."‡

Discoveries made by various travellers in Russia, during the last century, throw considerable light on the subject of mining and metallurgy as anciently practised in that part of the world. The remains of numerous mines have been traced by Gmelin, Lepechin and Pallas, on the southern and eastern borders of the Ural Mountains; and in them were found hammers and chisels of copper, as well as various instruments of the same metal, of which the uses are at present unknown. From the absence of any remains of masonry in the neighbourhood, these excavations are inferred to have been made by a nomadic people, probably the Scythians; and from no iron tools having been found in any of them, we may conclude that these operations were carried on before the conquest of Siberia by the Tartars, who effected the subjugation of that part of Asia, about 150 years before our era.§ Sledges made of large stones, to which handles had been attached, were also discovered, together with boars' fangs, with which the gold appears to have been collected, and leathern bags or pockets in which it was preserved. With such imperfect tools, the progress made must necessarily have been exceedingly slow, and in one instance, after reaching a band of rock and penetrating it for a short distance, the miners seem to have lost patience and abandoned the works. The pits or shafts are well made, about seven feet in diameter, and of a circular form, some of them being 20 fathoms in depth. The passages and props are also well executed, but the former so low and narrow, that they could only have been excavated with the greatest difficulty to the workmen. The ores when extracted were carried to the nearest rivulet for the purpose of being crushed and washed, which operations were probably dispensed with in the richest varieties, which were sometimes melted in the mines themselves, metallic copper, together with slag, and the tools employed in melting and refining, having been found in some of them.

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* Watson's Chemical Essays, iii., 265.

† Alonso Barhu.—Treatise on Metals, French translation, i., 272.

‡ Childrey's Britain, 1661.

§ Histoire Généalogique des Tartares.

Lumps of copper, which contain no traces of gold, have also been discovered, although the copper ores of the districts are found associated with that metal, and it is therefore evident that the ancient people who worked these mines were acquainted with a method of refining gold.

The smelting was effected in small furnaces made of red bricks, and of which Gmelin found nearly a thousand in the eastern parts of Siberia. The height and breadth of these were about two feet, and the width three. They were also furnished with holes in two of their opposite sides, the one for the introduction of bellows, and the other for the escape of the metal and slags. In the neighbourhood of the furnaces were found large quantities of broken pottery, together with numerous heaps of scoriæ, which indicate that operations to a very considerable extent, have at some period been carried on in that locality.

Gmelin likewise found in the same districts the remains of various furnaces which had been employed for the extraction of silver, and remarked that the lead with which it was associated had been thrown away in the scoriæ, whilst the whole of the silver was carefully extracted. By what means this was effected, in this particular case, is of course impossible for us to say, although it is highly probable that cupellation in some form was resorted to. Diodorus (III. 14) informs us, that gold was purified by being melted and heated in earthen pots, together with an alloy of tin and lead, to which salt and barley-bran were added, and that the fire was kept up during five successive days. Another ancient author* states, that gold was melted by a gentle fire with the addition of salt, nitre, and alum, and that the same process was employed for refining silver. It is, however, difficult to understand what action these substances, with the exception of the nitre, could have on the purification of silver and gold, and we may therefore conclude, that the action of the air was after all the chief means of oxidation employed.†

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* Hippocrates de Diæta, 193.

† The nitre of the Ancients was probably carbonate of soda.

In Britain silver mines were worked before the invasion of the island by the Romans, and gold must also have been well known to the inhabitants before the arrival of Cæsar, since coins of that metal were then in circulation. Cæsar and Strabo both state that the Britons obtained their copper from foreign countries, and we may hence infer that the art of refining this metal was either unknown, or little cultivated by our forefathers at that remote period. Iron is described by Cæsar as being so rare, that pieces of it were sometimes used as a medium of exchange, and almost as highly valued as gold; but a century afterwards it had become very common, as in Strabo's time, it was an article of exportation.* Tin was anciently the most celebrated product of Britain, and appears even at that time to have been extracted in considerable abundance, since it was the desire of obtaining possession of these mines, and becoming thereby independent of the Phœnician monopoly, which first induced the Romans to visit the island. Before the conquest of their country the Ancient Britons extracted this metal from its ores by methods which they had themselves discovered, and which were probably improved on by their conquerors.† The smelting process would seem to have been very simply conducted. The broken ore was placed in a hole in the ground, the sides of which were lined with pieces of wood, which, on being ignited, reduced the lead and tin, which were separated from the slags by being run off through a narrow channel into another receptacle. Many of these rude furnaces have been found in various parts of Cornwall and elsewhere, in which not only charcoal and slags have been discovered, but also portions of the reduced metal, which, in many instances, had, from long exposure to oxidising influences, again become partially converted into tin ore.‡ This very rude method must have been attended with considerable success, as the slags resulting from it have proved on examination to contain but a small amount of metal.§

From these and many other relics which have been met with in different parts of the world, we may infer, that although the arts of working the metals were carried on formerly on a much smaller scale than at the present day, the operations of the early metallurgists were tolerably successful, and that in spite of the rude apparatus which they employed, the results obtained by them were generally of a satisfactory nature.

That a great degree of attention was at a very early period bestowed on the manufacture of alloys destined for particular purposes, is proved by the uniform composition of the several cutting instruments examined; although it is evident that but little care was taken to obtain a correct standard for the early brass money, as many pieces of nearly the same date, and of similar value, differ materially in the amounts of the metals of which they consist. On this subject I shall offer no observations, as the object of the present paper is rather to shew the composition and proportions of the ancient alloys, than to enter into a discussion on the coins of antiquity, and I therefore leave this matter for the consideration of the numismatist and antiquarian, whose labours in that direction may possibly be, in some measure, aided by the facts elicited from the foregoing analyses.

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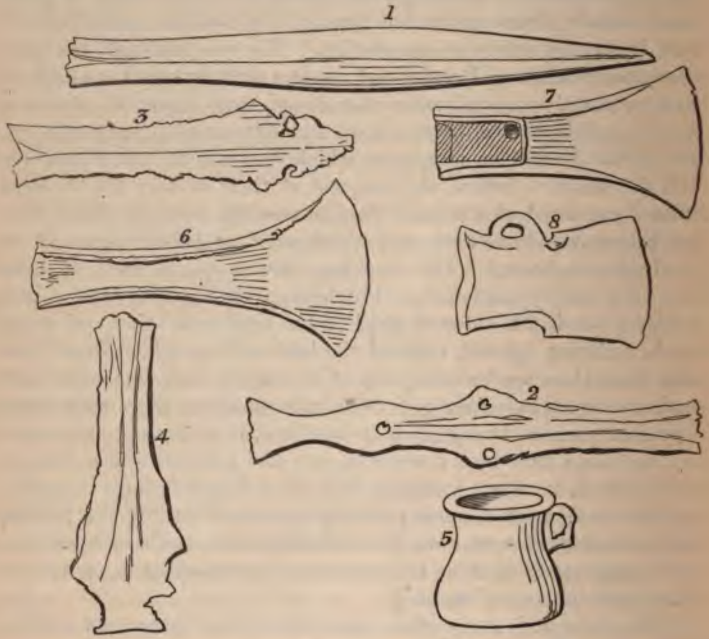
* Strabo, IV., 305.

† Strabo, I.

‡ Jews' house *tin*.

§ Pennant, I., 58.



No. 1. Sword-blade, found under Chertsey Bridge, Thames.
,, 2. A broken sword-blade, from Ireland.
,, 3. ,, ,, also found in Ireland.
,, 4. A broken spear-head, from Ireland, presenting the only specimen of unalloyed copper examined.
,, 5. A celt, with a socket for the introduction of a wooden handle and an eye, probably for the purpose of attaching a string.
Nos. 6 and 7. Celts, composed of a harder alloy, and without sockets.
No. 8. A celt, with socket and loop, found in Ireland, and made of a hard alloy. This specimen appears to have been sharpened by grinding.

Account of Observations on the Solar Eclipse of July 28, 1851, *made at Sebastople.* By EDWARD SANG, Esq., F.R.S.S.A., Professor of Civil and Mechanical Engineering, Constantinople. Communicated by the Royal Scottish Society of Arts.*

While engaged in preparing to observe the eclipse of the sun from Constantinople, I received a copy of a letter, of date June 5th, addressed by the Astronomer Royal to Mr Waddington, proposing a trip across the Black Sea, and accompanied by copies of the Suggestions to Astronomers, prepared by the Committee of the British Association, which was forwarded to me by His Excellency Sir Stratford Canning. Subsequently, I have learned that this was at the instance of the Secretary of the Royal Scottish Society of Arts, and, accordingly, to that Society I make my report.

The idea of a journey into Russia had previously crossed my thoughts, and, for various reasons, had been dropped; but on learning that my observation of the phenomena of the total eclipse might be of the least service, and that no one had been deputed from England to this quarter of the world, I laid aside all my preparations here, and resolved on a journey to the region of total shadow.

Unfortunately, His Excellency's note of date July 12th only reached me on the 15th, and the very next was the sailing day of the Odessa steamer; it was utterly impossible to complete my arrangements in time; there would be no other opportunity by steam until the 26th, and thus our only chance of reaching the Crimea previously to the eclipse, was by a sailing vessel; this chance, too, with the prevailing north winds, and the high state of the barometer, was a very small one. So long, however, as a possibility of success remained, I was determined not to abandon the enterprise. With a change of wind we might still reach Kertche or Theodosia, and make the observations from the quarantine grounds. I therefore proceeded at once to make the necessary preparations, and obtained a readily granted leave of absence from His Highness Ahmet Fethi Pasha.

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* Read before the Society, 24th November 1851.

On learning the state of matters, His Excellency the Baron Titoff shewed all the anxiety to assist us which could have been hoped from the most enthusiastic astronomer. After weighing in his own mind the almost impossibility of our reaching in time by help of a merchant vessel, M. Titoff made me the unexpected and most welcome offer of a passage on board the brig of war Perseus, which was about to return to Sebastople, and whose departure he proposed to accelerate. Since, even this with aid, our only hope lay in a change of weather, it is needless to say how gratefully I accepted so liberal an offer.

His Excellency M. Titoff having furnished me with letters which every where procured for me the most courteous assistance, we left the Bay of Buyukderé, under the command of Prince Chickmakoff, early on the morning of the 21st. Notwithstanding the most strenuous exertions, and the help of the steamer Molnia, it was not until noon of the next day that we succeeded in stemming the current and fairly launching into the Black Sea.

The anxiety attending such hasty preparations being now over, we had leisure to concoct our plans and to discuss the nature of the instruments which we had collected. The tedium of our voyage may be well relieved by an account of both.

The ingress of Mercury on the 8th November 1848 was beautifully seen here. I had the good fortune to study it with an excellent 4½ inch aperture refractor, by Plössel, belonging to Ohanes Dadian, Esq. Having had every reason to be satisfied with the performance of this instrument, and being desirous of leaving my own telescope for the use of my family, I applied to Mr Dadian, who at once most kindly conceded to me the use of the Plösselsche. We constructed a light octahedral frame of slender fir rods to fit upon the eye-piece of the instrument, and to carry a card on which a graduated circle was traced. The intention was to receive the sun's image on this card, under a tent, and to watch there the progress of the phenomenon, so as to avoid fatiguing the eyes; the graduated circle would enable us to refer any appearance to the proper place on the sun's disc. With the lowest power, the sun's image on this screen is about 7½ inches in diameter; the spots with their surrounding umbrae, the variegation of the sun's surface, and its gradual diminution in apparent brilliancy towards the edge are beautifully distinct. In this way we had examined the ingress of Mercury; the progress of the planet was distinctly followed without any appearance of that distortion which is mentioned in the Committee's suggestions. Hence I expected that this instrument would afford conclusive evidence concerning the nature of the beads.

The owner of this refractor procured from the same maker a splendid equatorial of 14½ inches aperture, completely mounted, for the Ottoman Government; this magnificent instrument has not yet been set up.

For the purpose of determining our geographical position, we had an 8 inch portable astronomical circle, by Adie of Edinburgh, the performance of which has long given me the greatest satisfaction. It is read to 10″ with three verniers, both in altitude and in azimuth, and is fitted with all the adjustments which an instrument of that size can require. This was accompanied by a chronometer, whose rate had, for several years, been found sufficiently steady, with a slight over-compensation, that is, a tendency to go faster in summer. Its winter rate had been 0s. 9 losing, and its summer rate was 0s. 24 losing. For comparison we had also a pocket-watch, whose rate was as close as that of the chronometer. A mountain-barometer for correcting the refraction, a pair of Nicol's eye-pieces, darkening glasses, boxes of tincture of litmus of various thicknesses, stearine candles for comparing shadows, and other odds and ends completed the apparatus.

Encountering only light winds and calms, we saw our prospects of reaching Kertche gradually wane; computations for Theodosia were made, and instructions were drawn up for a nearly tangential phase. Latterly we had been hoping against conviction, when, on sighting the south point of the Crimea, our hopes were revived by a fresh breeze.

With the sunset of the 27th, however, the wind again fell, and the morning of the 28th dawned upon us with the impossibility of reaching even Theodosia. There was still a small probability of making Sebastople, the only other place at which we could set foot on shore: so after a short consultation the vessel was put about.

Computations were now made for our new haven of hope, and corresponding instructions were drawn up. The rate of the log and our distance from the lighthouse of Kherson were anxiously compared; the light breeze gradually stiffened; the chronometer was coming up to the computed time of commencement, and our race against the moon promised to be a very close affair. We rounded the point of Kherson, and just as the quarantine bay was opened up, the index pointed to the time of look-out. Meantime, in anticipation of our anxiety, our commander had caused the boat to be lowered and the instruments to be handed down; and almost simultaneously with the first appearance of the moon's edge came the intimation " boat ready."

A very smart pull brought us to the quarantine while the vessel continued on her way. To choose our stations, open the boxes, set up the instruments, and compose ourselves for observation, occupied some time and gave occasion for anxiety; but within forty minutes from the beginning of the eclipse we were all settled to our duties.

The party consisted of the first lieutenant, Mr Gregory Jelesnoff, who had engaged to measure the distance between the cusps, accompanied by Lieutenant Andreowsky, with a chronometer; of Mr Zazebin the first sailing master, who had undertaken to measure the breadth of the illuminated part, accompanied by Mr Daïn, the second master, with another chronometer; and of myself and son who were occupied with observations on the appearance of the beads.

As our computation had given 38″ for the least breadth of the illuminated part, there was no other physical phenomenon likely to come under our notice; so, excepting a glance at the aspect of the surrounding scenery, and an attentive examination of the cusps in search of any appearance of the moon's limb beyond the sun's disc, of which there was no trace, we gave our whole attention to the appearance of the beads.

My previous opinion on this subject was very decided. I had carefully studied the annular eclipse at Edinburgh, with an excellent reflector carrying a power of about 100; had seen the well-defined angular projections of the moon cut the sun's edge, and followed their disappearance to the last without perceiving the slightest distortion of the solar limb, or of any of the spots which were successively eclipsed. At another time, with the same instrument, I observed an occultation of Saturn. The end of the ring, which then shewed almost as a line, was seen gradually to shorten, and, when the moon's edge came up to the disc of the planet, the sharp angular contour of a mountain was plainly seen and observed by several of our party, while the planet retained its form unchanged. For these reasons, while preparing the notice of the eclipse of 1847, which was almost central here, I drew the attention of our observers to the ruggedness of the lunar contour as sure to produce the appearance of a string of brilliants, about the time of each of the internal contacts. In all matters of difficult observation, one's pre-formed ideas go for a great deal; for this reason I have stated mine.

On examining the edge of the sun's image made on the screen, there was found a very extensive trembling, subject to sudden fluctuations, as thin hazes and fleecy clouds passed before us: the depth of the undulations varied from 5″ to 8″ or 10″. This undulation prevented any accurate measurement of the altitude of the lunar ridges, although it left their existence sufficiently apparent; the cusps also were rendered indistinct. Had we not been acquainted with the excellent performance of the instrument, we might have complained of great spherical aberration, as the large and palpable undulations were accompanied by a minute under-tremor which gave to the outline a permanent indistinctness analogous to that arising from a bad adjustment of the focus.

Towards 3^h 15^m Greenwich time, the cusps shot out and retracted considerably with a leech-like motion, and at 3^h 33^m

separate roundish beads began to appear; these became more frequent as the angle of intersection grew less.

On attending closely to that part of the moon's edge, which was about to pass off the sun's disc, whenever we found an indentation and followed it up to the cusp, the hollow was seen to separate from the rest of the illuminated surface, and to assume a roundish form, which fluctuated with the undulations. Carefully observed, it seemed that the indistinct roundness of the form was due to the retention, by the retina, of the rapidly succeeding impressions.

At the incoming cusp again, whenever a bead made its appearance and was followed until it united with the rest of the illuminated surface, that portion of the moon's limb which had come on with it was found to be deeply indented. The last of this class of phenomena which we noticed was so distinct, as of itself to be decisive. A large and well separated bead was seen coming on, and its distance from some irregularities on the moon's edge was estimated. After the bead had amalgamated, that part of the moon's edge which had the same distance from these irregularities was found to be marked by two prominences whose height above the general surface might be 3″ or 4″, and whose summits were at the distance of 8″, with a deep hollow of about 6″ between them.

On the whole, the impression on my mind was confirmatory of my previous opinion, that these detached portions of light result simply from the ruggedness of the moon's edge. I had not previously had an opportunity of witnessing the appearance under such favourable circumstances. What I have now seen has convinced me that the distortions arising from the unequally heated state of the atmosphere, or from the imperfections of the telescope, have been taken for something else.

The decision of this question is not without important results in practical astronomy, for the instant of occultation of a star must be subject to an uncertainty depending on the configuration of that part of the moon's limb on which it falls; and this uncertainty must pervade all determinations of the longitude by this means. During the eclipse there was seen a range of elevation measuring in length about 150″, and of which the altitude was some 6″ above the general outline. Now the moon's mean motion is roughly one second of arc in two seconds of time, and the occultation of a star by this ridge would therefore have preceded by no less than 12″, the computed occultation; and even by a longer time if the appulse were oblique. A very small change of latitude also will bring the observer opposite to a different part of one of these irregularities.

This unevenness of outline also opens up a discussion as to what is to be considered as the moon's diameter. With a power of only 50 the bright edge is seen as an irregular line not merely indented and studded with prominences, but irregular in the large way, that is, deviating greatly from the circular form. Photographic portraits of the moon in various states of her libration would be of immense value in enabling astronomers to compute exactly an occultation. On our globe the ocean spreads over the greater part of the surface, and, by its unity, determines the general form; but on the moon there is nothing analogous. Even those spots which appear with a low power as extensive plains, are found, when more narrowly examined, to be undulated and even studded with small volcanic mountains. What then is to be regarded as the moon's diameter, and from what starting point are we to reckon the heights of the lunar hills?

To return to our eclipse; the rapid formation of heavy clouds warned us of the propriety of determining our local time, for which purpose the altitude of the sun's lower limb was taken with Adie's circle, face east and face west, and then the end of the eclipse was waited for; a few seconds before it happened the sun's disc was completely concealed by a cloud, and thus we had neither the beginning nor the end from which to compute our longitude.

On the evening of the 29th we determined the latitude from the observed altitudes of α Polaris and of Vega to be north 44° 36′ 17″. The chronometer was also compared at the same time with the local siderial time, and thence, by help of observations made here before our departure and after our return, the longitude was found to be 18ᵐ 04ˢ east of my present residence.

As I had hitherto made no very careful observations to determine my longitude here, not anticipating any protracted stay, I resolved to postpone sending my report until an opportunity should have occurred of verifying it. For this purpose the occultation of 74 Aquarii was observed on the 9th September, and at the same time the right ascension of the meridian was taken by help of the altitudes of α Polaris, Arcturus, and Vega. This plan I was forced to by the want of a distant night-signal for my meridian. On making the computations *strictly* without any approximate operations there came out lat. 41° 03′ 06″, lon. $1^h\ 55^m\ 51^s$, which thus gives for the longitude of the quarantine station at Sebastople $2^h\ 13^m\ 55^s$.

As we had not been fortunate enough to observe either of the contacts so as thence to deduce directly the longitude of Sebastople, we were thrown upon our other resources, viz., the angular distances of the cusps, and the breadth of the illuminated part. Seeing, however, that with the sextant we can hardly come within 15″, especially when we use darkening glasses, and that this would give an uncertainty of 30^s in longitude; and seeing also that towards the end of the eclipse the cusps approach each other very rapidly, it followed that our most favourable observation was the last made by Mr Jelesnoff. From it, and from the observations on the altitude of the sun's lower limb, the longitude was found to be $2^h\ 14^m\ 08^s$, only 13^s more than that found by the chronometer.

All of these results indicate a greater longitude for Constantinople than that usually given in the books, for which reason I have deferred the transmission of this report, awaiting the opportunity of another occultation. Having prepared the preliminary calculations for that of B.A.C. 6607, I have just been disappointed by the otherwise welcome appearance of rain-clouds. The next occultation visible here is that of ξ Ceti on the 11th, for which, considering the chance of broken weather, it is scarcely worth while to wait.

In conclusion, I have to regret that an unaccountable delay in the transmission of the "Suggestions" should have prevented me from making arrangements in time for the packet, and that, notwithstanding the energetic assistance which was accorded me by His Excellency Baron Titoff, and by the officers of the Perseus, we were unable to attain the principal object of our mission. There is, however, this consolation, that, as the Russian astronomers had made complete arrangements, no loss to science has accrued from our misadventure.

CONSTANTINOPLE, October 2, 1851.

On the Scratching of Rocks by the passage over them of Sharp Detrital Matter. By Lieut.-Colonel PORTLOCK, F.R.S., President of the Geological Society of Dublin.

As the old opinion regarding the effect of the passage of detritus over the surface of rocks in forming the scratchings, &c., so generally observed, is again brought forward by our friend the present President of the Geological Society of Dublin, we doubt not our readers will be interested by the following details, as given in Colonel Portlock's Address,* which has just reached us.

"In my communication on Bantry Bay I brought under your notice one of those examples of the scratching of rocks, by the passage over them of sharp detritic matter, the surface having been previously worn smooth and partially polished by a similar action. The example, which I described from my own personal observation, was taken from one of those bluff clay banks so common in Bantry Bay, the interior portion of which—meaning that part within Whiddy Island—appears to have been formed by denudation of a comparatively recent date, or subsequent to the formation of post-tertiary deposits. The wear of this great mass of gravelly clay studded with boulders, or, in other words, of boulder-clay, is still continuing, and must continue, so long as any portion of it remains within reach of tidal action. As the level of the water rises, the waves beat upon the base of the clay cliff, and gradually undermine it, until at length the top falls in, and for a time the base is protected by the fragments. When, however, they have been washed away, the work of destruction is renewed, and slice after slice of the cliff or bank is thus removed, until, at length, the base retires beyond the action of the higher tides, and the cliff, exposed only to ordinary atmospheric agencies, finally crumbles into a slope fitted for the preservation of statical equilibrium. In the progress of this wear it is usual to find the boulders and larger gravel of the clay heaped up as water-worn shingle at the base of the cliff, the finer matter or clay having been washed away. It was at the base of a bluff headland of this boulder-clay, which is only exposed to the action of the waves in very high tides or in storms, and is, in part, protected by a bank of water-worn shingle, which had once been imbedded in it, that I observed a portion of the rock laid bare, which, far from exhibiting the jagged edges of the strata habitually exposed to the wear and tear of the waves, was smooth and rounded in its surface, and further marked by fine sharp scratches, varying in their parallelism according to the relative positions of the slopes of the rock and the consequent direction of the scratches. It further appeared to me that these scratches passed under the clay; and I therefore assumed, as probable, that they had been made by substances moving with or imbedded in the clay. It will be understood that I endeavoured merely to state a fact, and not to describe historically the phenomena with which that fact would be naturally connected. It is right, however, that I should now observe, that in my Geological Report on Tyrone and Londonderry, published in 1843, I have distinctly pointed out that the phenomena of drift are such as cannot be explained by any one movement of water, whether diluvial or fluviatile or marine, but are the results of actions often varied in their direction and amount, in a manner very similar to that which can be traced in more ancient deposits. In the illustrations to that work I have given examples both of contorted strata and of cross or false stratification in drift, and have contrasted them with similar appearances in secondary sandstone rocks. It is not the time to enter into an explanation of such phenomena further than to urge that they prove a long continued and regular mode of deposit, implying a sequence of strata. Nor do I see anything in their character which can, *a priori*, decide in any case whether they preceded or followed the deposition of boulder-clay. Local evidence has, however, proved that in some cases the clay preceded the stratified sands and gravel; but it is not impossible that, in other cases, marine currents may have swept over the surface of rocks, and hurried with them sand and shingle prior to the deposition of boulder-clay. If such were the fact, the surface of a rock may have been smoothed and polished by the friction of the sand passing over it, and subsequently grooved and scratched by the more slow movement of glaciers or of boulder-clay.

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* *Vide* Journal of the Geological Society of Dublin, vol. v., Part 1st, 1851.

"I have now come to the point where I may fitly notice the paper or letter of a respected fellow-member, your former president, Mr Robert Mallet, brought forward on the 11th December, in which he lays claim to priority in an explanation of the mode in which rocks have been grooved and scratched. Mr Mallet states that, in company with Professor Oldham, he examined, in May 1844, the cuttings of the Drogheda Railway made through the calpe, in the neighbourhood of Killester, and observed numerous scratches in the rock, and on the lower surfaces of boulders imbedded in the clay and gravel beds above it; and some of the scratches appeared to indicate that the superincumbent clay had been forced *en masse* up hill over inclined calpe beds; and that he concluded, from the evidence in general (and communicated his views on the subject to Professor Phillips and the Council of the Society, on the 5th June 1844), that the scratches had been caused by the movement *en masse* of 'the clay and gravel beds over the rock beneath, and that the scratches upon the latter, as well as those upon the large boulders reposing on the rock and imbedded in the clay, had been produced by their being carried over the rock along with the moving masses of clay and gravel.' On the 12th Nov. 1845, Mr Mallet read a paper on the subject to the Society, and then 'enunciated the doctrine that the lateral movement of masses of mud, sand, and gravel, while in a wet and plastic state, either under the sea or upon land very recently elevated above it, had been the great agent not only in the almost universal scratchings observable upon the surface of the rocks of every part of the earth, but had been also the means of transport of the far larger proportion of the boulders and greater drift masses that cover the earth.' Mr Mallet showed the close similarity that, in his opinion, exists between the motions, internal and external, of a moving mass of mud or sand and gravel, or of vast landslips, and of those of glaciers; and at the Cambridge meeting of the British Association, again brought forward his views, adopting the term 'mud glaciers,' as illustrative of this supposed similarity."

It is thus on these grounds that Mr Mallet claims priority of discovery, and complains that many geologists have adopted his mode of explanation without acknowledging or referring to that priority; and it becomes necessary, therefore, that I should set before you so much of the history of this branch of geological science as will be necessary to understand and to decide on this claim.

It is scarcely necessary that I should here observe, that by early geologists, with some exceptions, the existence of gravel and sand was ascribed to diluvial causes, and that scratches or marks of friction were considered evidence of diluvial currents. In Catcott, for example, the transport of detritic matter by the diluvial stream is strongly urged, and the wear of the strata by diluvial waters. In like manner these effects were ascribed to the movements of water, when Hutton and his pupils Playfair and Sir James Hall, had advanced and illustrated the theories of elevation of mountain masses and marine currents. Mr Greenough (1819), in his critical essays, observes,—"These theories refuted, there remains, in explanation of the phenomena of boulder-stones, the theory which attributes their occurrence, like that of ordinary gravel, to the action of running water. The arguments in favour of that doctrine are, that boulder-stones are evidently not *in situ;* that they are, for the most part, trace-able to the parent rock, which, however distant, is always at a higher level than themselves; that they often rest upon beds either secondary or alluvial; and, lastly, that the upper surface of rocks protected by soil is, in many cases, so furrowed as to resemble a wet road along which a number of heavy and irregular bodies have been dragged, those furrows generally agreeing, in parallelism, both with one another, and with the ridges and large features of the district."

Mr Greenough, not considering the force of running water, either as exhibited in the torrents of rivers or in the sea, sufficiently great to account for such results, ascribes them to the deluge. Hutton had ascribed them to the tumultuous rush of water consequent on great debacles, the result of sudden elevations of mountain chains and masses.

Dr M'Culloch, in his System of Geology (1831), observes in his chapter on Changes in the Disposition of the Sea and Land, "But I must not omit one argument supposed to afford a strong evidence of such diluvial currents; namely, the scratches or marks of friction already noticed in rocks where water does not now flow. Many of the quoted instances occur in places where rivers have once run, under the changes already pointed out; while if the others confirm the former existence of currents that could not well have been rivers, they are not competent to prove such movements of water as I have here rejected (diluvial). I shall inquire further of them presently, as the probable *effects of heavy* alluvia transported by water under other causes," an idea which is similar, if not identical, with that of Mr Mallet.

Again, in his descriptions of alluvia, Dr M'Culloch has one section denominated "alluvia of descent." He says,—"The necessity of revising the alluvia has caused me to give this name to those which are produced by a combination of gravity, aided by rain, with the ordinary disintegration of the summits of mountains. These occur in all declivities, and consist of clay and sand, with fragments often of great size, which, if generally angular, are sometimes slightly rounded, from partial attrition or decomposition. Their real origin is indicated by their position, by tracing the progress of the operation, and by the nature of the substances. Their depths vary according to circumstances, and they often descend so far as to occupy the valleys beneath." "As these appearances occur in very gentle declivities, as in Cumbray and Isla, or almost on level ground, as near Comrie, here is a demonstrated cause of even transportation which geology has overlooked. That even boulders may have been gradually moved in this manner to great distances from the parent rock, is abundantly obvious; and I may here say, once for all, that whatever volumes may have been bestowed on these travelled blocks, there is no reason for separating them from the several classes of alluvia to which they belong,"—an idea again identical with that of Mr Mallet. M. Dausse, in his Essay on the Chaine des Rousses (1834), describes the mountain gorge of Flumay, which is formed by the junction of the granitic and gneisose rocks of the great chain of the Rousses with the slate escarpment of Côte-Belle. This deep ravine narrows at its bottom almost to a line, and has there a steep descending slope. On the left, and towards the head of the gorge, the gneisose beds, which are above, have been greatly dislocated, and have produced huge accumulations of debris at the bottom. On the right, "the very bowels, as it were, of the mountain de Côte-Belle are exhibited as the various beds crop out in the steep escarpment. Strangely, indeed, is this escarpment ravined and grooved and notched by the projecting of its several beds, and shaped into rugged asperities and bold needles, which are incessantly giving way and falling to the bottom. It is here that we find torrents or *coulées de débris*, which the rains and great thaws have the power of moving. In this passage, M. Dausse almost seems to have Mr Mallet's illustrative image of a glacier in his mind, but he contents himself with merely stating that huge accumulations of debris are made to flow down the course of a steep ravine by the increased power of water consequent on heavy rains or sudden thaws.

Quotations of a similar character might be multiplied, as the first mode of explaining the polishing and grooving of rocks was naturally to ascribe them to the passage of drift—

or, as it was then considered, or at least called, diluvial matter—over them.

D'Halloy (1831), in his Elements, states, that M. Brongniart had observed portions of the primordial rocks (granites, &c.) where the surface had been polished and grooved in the direction of the trainées of debris, as if it had been worn by the passage over it of the blocks composing them. These trainées in Scania and Smalande form longitudinal hills, which the Swedes call *as*, or *ose;* our Irish escars. M. D'Halloy classifies, from the observations of M. de Beaumont, the drift or diluvium thus:—"It apparently occurs in three different forms. In the bottoms of valleys it appears as terraces, separated by a longitudinal depression, in which, like a secondary valley, is the ordinary watercourse; in plains it is spread out in vast horizontal 'nappes,' or sheets; and in mountains and hills it occurs as erratic blocks. It cannot be said that it exhibits a true stratification, though its masses often exhibit a partial parallelism. M. de Beaumont considers it generally in unconformable stratification with the strata which it covers; and, it may be added, that excepting where secondary valleys have been worn in it, the tendency of drift has been to fill up hollows and inequalities, and to reduce the surface of the earth to horizontality.

It will be observed that the proximate cause of the polishing and grooving rocks was naturally sought in the passage of drift over them, and that to explain the cause of the movement of that drift was the real difficulty. Fluviatile, marine, and diluvial currents have all, in turn, been called into action; and had our learned member, Mr Mallet, given us a clear and satisfactory explanation of a new mode in which such large masses of drift might have been put into motion and spread over the surface of the earth, he would, indeed, have deserved our thanks. His reference to the movement of landslips does not appear to me such an explanation, as it involves a generalization similar in character, and certainly more defective than that of Agassiz, in respect to glaciers.

It was, indeed, principally to supply the defective cause of the motion of drift that Agassiz endeavoured to generalize the phenomena of glaciers, so as to make them consistent not only with the drift of mountain valleys, but also with the immense detritic coating of the level plains below them. The effect of his first exposition of the phenomena to British geologists, who were not, like those of the Continent, familiar with the writings of Hugi, Charpentier, and Venetz, was truly surprising; and many of the most distinguished, headed by Dr Buckland, entered upon the search for glaciers with the utmost enthusiasm. Nor has the subject lost its interest even now, as almost every season produces new examples of former glacial action on the mountains, humble as they comparatively are, of the United Kingdom. Agassiz was not originally an advocate of the glacier theory, but, as he informs us, considered the explanation of drift and its effects by marine currents more simple and rational. Personal intercourse, however, with Charpentier soon brought him to concur in the opinions of that author, and he became their most zealous and successful expounder. In one respect, the advocate for glacial action has this great advantage, that he can appeal to nature for proofs of the transporting power of ice—whether on land, as exhibited in the glacier, or in water, as manifested in the iceberg, or in the icefloe; and the real question, therefore is, whether that transporting power is equivalent to the effects which have been produced. On this point we may freely admit, as had been done long before, that the transport of large erratics is best explained by referring them to icebergs or icefloes. In like manner, the grooving and polishing of rocks within mountain chains, and even the arrangement of mountain drift, may be fairly ascribed to glaciers; but a doubt may be reasonably expressed whether either or both of these actions can explain the arrangement of the more widely spread drift of plains; and we are forced to call into our aid marine currents, more especially tidal currents, of which we shall again speak in the sequel of these remarks. It is right, however, to inquire first into the peculiar relations of the glacier to the effects we are now studying. M. Agassiz states (Etudes sur les Glaciers, 1840, p. 184), "The bottom of the glacier does not always rest immediately on the rock or ground, but is usually separated by a bed of sand or mud, which, according to its thickness, contributes more or less to the formation of terminal moraines. This bed proceeds from the fragments of rocks which fall under the glacier, either through its numerous cracks or by its margins, and are triturated into minute particles by the grinding action of the glacier as its moves along its channel. When glaciers move over granitic rocks, this bed is composed of very fine, white, and very loose sand; when, on the contrary, the moraines, which supply the materials, have proceeded from calcareous or slaty rocks, the bed is dark and pasty. It is to the small gravel contained in this intermediate bed that the characteristic striæ of polishing rocks must be ascribed. In the upper valleys, this bed is frozen and adherent to the ground, whilst in the lower it is thawed. Independently of this bed of sand or mud, it is not unusual to meet under the glaciers a bed, more or less considerable, of small rounded blocks, varying from the size of an ordinary pebble to a diameter of six inches or a foot. These rounded boulders, which have been evidently triturated and worn like the sand by the movement of the glacier, strongly resemble the gravel beds of what have been called diluvial deposits, and were they not so clearly connected with the glacier action, would be ascribed to powerful torrents. These beds of pebbles vary considerably in different glaciers, and are specially well exhibited under the glacier of the Trient, where it is manifest that they proceed from the detritus of the sides of the valley, and are renewed continually as the more ancient portion of the bed is pushed forward to the lower part of the valley—a fact which negatives the supposition that the glacier may have been formed on a tertiary deposit."

M. Agassiz also points out that fragments encased in the ice act as files or rasps upon the rock when the glacier is in actual contact with it—a mode of operation which has been reasoned upon, whilst the other, or that in which a mass of detritus is moved with and under the glacier, has almost escaped notice.

Agassiz indeed says—"We have seen that the bed of mud and gravel, which is intermediate between the glacier and the bottom of the valley, contains a quantity of small fragments of very hard silicious rocks, and, being moved on by the mass of the glacier, act as so many diamonds on the rock below, scratching its surface, whilst the mud and ice polish it. If," he adds, "the striæ and grooves under existing glaciers ha been laid bare, and thereby made as distinct as those of extinct glaciers are, the connection between the striæ and the action of glaciers would have been long since admitted, and an explanation of the phenomena neither sought for in currents of water or of mud."

I shall quote no further from M. Agassiz, and I have dwelt so long on the subject merely because I consider it of high importance to determine the real mode of deposit of the various descriptions of drift; and though I have observed a disinclination in many geologists to dwell on this or other branches of physical geology, I cannot but feel that it must ever be a reproach to geology if it cannot succeed in unravelling the difficulties which still obscure our explanations of drift, an operation which has taken place almost at the moment of man's birth. My predecessor in your chair had also occasion to refer to this subject in his address; and with his observations I partially agree, partially disagree. I cannot agree with him when he considers M. Martin's argument defective, in illustrating the possibility of glacier action in the mountain near Loch Lomond, at an elevation of 2400 feet, by the discovery of such action in the Alps, 2468 feet above the bottom of the valley which contained it. There is evidently no analogy between the case he adduces, namely, that as one rock (protogine, for example) occurs in one district, the statement of its occurrence in another might be thereby established. Doubtless were some strange and apparently anomalous rocky compound said to have been found in some particular district, our belief of the possibility of its existence would be aided by a knowledge that it had been found in some other similar district; and in this way the glacier phenomena of the Alps may reasonably be called in to illustrate those of the Scotch and other mountains. I do, however, agree with my learned predecessor—and I had long since expressed that opinion—that it is dangerous, nay, unphilosophical, to view the phenomena of all "so-called drift deposits only in connection with, and as illustrated by, the phenomena of Alpine glaciers." On a former occasion I stated, as Sir R. Murchison has also done, that the composition of our ancient conglomerates and sandstones is, from the absence of boulders, such as not to lead to a belief that even glacial or ice action had existence at the time of their deposit; and if this opinion be correct, accumulations of ancient drift in sand, gravel, and mud must have then taken place through the agencies of fluviatile and marine currents alone. But let me ask, has the recent removal of any of the secondary or tertiary strata from the rocks below them, either by quarrying or fluviatile action, laid bare surfaces worn in the manner which has been described? I have seen evidences thus displayed of the ordinary action of water, but I have not seen the polished or striated surfaces. Often, for example, may be seen on the sloping side of the beds, the surface of micaceous schist, when recently bared by the removal of superficial strata, still exhibiting the well-known ripple marks, but no transverse striæ or grooves. I throw out this observation in the hope that the absolute antiquity of such markings may be defined. Whilst, however, I cannot limit the phenomena of drift to any one glacial cause, I must admit and acknowledge the vast importance of the recent study of glacier action, as without the demonstration of the more extended existence of ancient glaciers it would be impossible to satisfy the mind that a truly glacial epoch had occurred in the earth's history. The establishment of the former extension of glaciers naturally proves the greater amount of general cold, and prepares us to admit the floating icebergs and icefloes, which are assuredly the most natural and efficient means of transporting the huge erratic boulders which have been spread over our now dry land. Such phenomena are now exhibited by the icebergs of our own seas, which convey fragments of rock thousands of miles from their natural seat; and would it not be truly unphilosophical to deny the possibility of such agencies at more remote epochs, or to refuse the corroborative evidence which ancient glacier action adduces in its support. But whilst the glacier and the iceberg were performing their parts, the river and the seas were not idle; and thus the true explanation of drift must combine the actions of all. One of these, namely, the simple action of the tidal current, seems scarcely to have been noticed in reference to this subject, though it has, doubtless, co-operated materially in producing some of the results observed. Almost every bay on our coast may afford evidences of the accumulation of gravel and sand by tidal currents; and it is very curious to observe how the shingle, or marine gravel, is sometimes moved over a smooth surface of sand. Nor is this the only effect, as I was enabled to observe, to great advantage, the action of the moving gravel in producing grooves in more solid substances, as exhibited in the breakwater at Southsea Castle, near Portsmouth, which has been worn in the most remarkable manner in deep parallel grooves, so as to assume the appearance of the most complicated mouldings. I have no doubt that a similar grooving takes place in ordinary rocks when favourably situated as regards the tidal current; and I would, therefore, suggest to every observer of such phenomena the inquiry, whether the grooving, as regards its physical position, is most nearly in relation to the action of a land glacier or to that of tidal currents.

Nor must fluviatile action be overlooked, as its power is very great under fitting circumstances. For example, can it be doubted that such a river as the St Lawrence must, both by its waters and by the masses of ice it bears along upon them, convey large quantities of detritic matter, and arrange that matter at the bottom of the lakes in a manner very similar to that observed in the drift of our plains and estuaries. Other evidences of fluviatile action in pot-holes, &c., as pointed out by that eminent American geologist, Professor Hitchcock, should not be overlooked. On solid rocks the action of rivers is small, but on the softer secondary strata, and on drift, it is considerable. In these latter cases they are modifying agents, removing and readjusting ancient drift, so that it is to more ancient rivers, or more ancient causes generally, that we must ascribe the drift itself. In making our selection between these causes we must not forget that a mere present difference of level between the point observed and the bottom of the valley or the stream running in it, is not a sufficient reason for rejecting the evidence of glacier action, as subsequent elevation has, doubtless, raised up the whole. In the glacial period when, as it is presumed, this extension of glaciers occurred, it is highly probable that our mountains were less elevated, whilst the limit of eternal snows was brought nearly to the level of the ocean. If, then, I consider a glacier as a true motive power applied by nature to transport drift, I consider it only as one power among many. I look upon it also as auxiliary to other glacial agencies, as it is the carrier by which detritus is conveyed from the mountain top and valley, until it is confided to the iceberg or icefloe, to be floated away to other and distant regions; but even with these restricted views of the geological agency of ice, it is evident that our knowledge of the phenomena connected with it cannot be too much extended; and I am happy, therefore, to see that it continues an object of zealous research.

On the Remains of Druidical Temples near Penzance. By RICHARD EDMONDS, Jun., Esq.*

Having in former communications described the dwelling places, and tombs of the very ancient inhabitants of this neighbourhood, I will now speak of their Temples—those erections which consisted originally of nineteen detached stones, placed upright, from 3 to 5 feet above ground, in rude circles, varying in diameter from 65 to 80 feet, and called by antiquarians "Druidical Temples," but by the neighbouring population "nine maidens," an abbreviation doubtless for "nineteen maidens." Borlase has noticed four of these within 5 miles of Penzance, all of which are still to be seen.† (Here the author minutely describes the four temples.)

These four temples are not the only ones in Britain wherein the number 19 stands so prominent. In Stonehenge the inner oval immediately around the altar consisted of precisely nineteen stones (see the plate in Dr Stukeley's Stonehenge, p. 20). So, too, the temple of Classerniss, in the isle of Lewis, "called a heathen temple," consisted of an avenue of nineteen stones on each side leading into the circle of twelve others.*

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* *Vide* Penzance Natural History and Antiquarian Society's Report for 1850.

† Antiq., p. 181.

I will now cite a passage from Diodorus Siculus,† in support of the general opinion that these circles were temples of the sun. The passage begins with an apparent reference to Mount's-bay, the most southern and the mildest part of Great Britain, and the only place in this island considered to have been frequented by the ships of the Phœnicians and Greeks:—

"Amongst them that have written old stories much like fables, Hecatæus, and some others say, that there is an island in the ocean over against Gaul (as big as Sicily) under the arctic pole where the Hyperboreans inhabit; so called because they lie beyond the breezes of the north wind—that the soil here is very rich, and very fruitful; and the climate temperate, inasmuch as there are two crops in the year."

That Mount's-Bay is the place alluded to by the Grecian author, may be inferred from the fact of its still producing much earlier, and therefore more crops in the year than any other part of Britain. But to proceed with the passage from Diodorus:—

"They say that Latona was born here, and therefore that they worship Apollo above all other gods; and because they are daily singing songs in praise of this god, and ascribing to him the highest honours, they say that these inhabitants demean themselves as if they were Apollo's priests, who has there a stately grove and renowned temple of a round form, beautified with many rich gifts: that there is a city likewise consecrated to this god, whose citizens are most of them harpers, who playing on the harp chant sacred hymns to Apollo in the Temple, setting forth his glorious acts." "The sovereignty of this city, and the care of the temple (they say) belong to the Boreades, the posterity of Boreas, who hold the principality by descent in a direct line from that ancestor."

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* Borlase's Antiq., p. 190.

† Book ii., chap. iii. Booth's Translation, p. 139.

The city and temple here referred to are supposed to have been those of Old Sarum and Stonehenge, and to have been erected under the superintendence of the Druids who came to Mount's-Bay from Canaan in Tyrian ships, and were received as priests by the aborigines of this island. The Druidical temples, however, in the neighbourhood of Penzance, being of much ruder construction, and formed of unhewn* stones, are considered still more ancient than that of Stonehenge, and to have been erected by Druids who had migrated from Canaan before the Jewish temple was built, and when the Jews had only their tabernacle, the court of which, where the victims were slain, being, like our Druidical temples, all open to the sky, and inclosed by pillars placed at distances of 5 cubits, or about 9 feet from each other, the object in each case being apparently to exclude all who were not especially engaged in the sacrifices, and at the same time to allow the people on the outside to behold what was transacting within; for the Jews believe that the victims were slain in sight of all the congregation, and as the court could not hold a tenth part of the congregation, it seems probable (Scripture being silent on the point) that the pillars from which the curtains (5 cubits in breadth) were suspended, were, like those of our Druidical temples, sufficiently low to allow the people to look over them. The circular forms of the latter might be traced to the worship of the sun. It is also to be observed, that the Druidical priesthood resembled that of the Jews, in being confined to the descendants of one man, as recorded in the quotation.

The passage, after mentioning that the Hyperboreans used "their own natural language," and had "of long and ancient time a special kindness for the Grecians," concludes with the following statement:—"They say, moreover, that Apollo once in nineteen years comes into the island, in which space of time the stars perform their courses and return to the same point, and therefore the Greeks call the revolution of nineteen years the Great Year."

This mythological reference to the cycle of nineteen years, at the end of which the new and full moons happen on the same days of the year as they did at the beginning, is very remarkable, for by it Christians have always ascertained the days of their movable festivals, and the Greeks adopted it for the like purpose in 433 B.C., Meton having obtained the first prize at the Olympic games for its discovery. Now Meton may have derived it through Hecatæus from Britain, as above-mentioned, and the British Druids may have had it from the Jews, whose year in the time of Moses consisted, like our own, of 365 days, and whose great festival of the Passover was (like ours of Easter) regulated by the moon. It is, I imagine, to this cycle of nineteen years that the number 19, so prominent in our Druidical temples, refers.

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* Ex. xx., 25.

On the Constitution of the Atmosphere. By M. LEWY. Read to the French Academy of Sciences.

The memoir which I have the honour to submit to the Academy contains the results of a series of researches on the constitution of the atmosphere, executed between France and New Granada, and from the coast up to 3193 metres above the level of the sea.

The analyses were performed by the new process of M. M. Regnault and Reiset, which consists, as is well known, in analysing the air by volumes. To measure the elastic forces of the gas I employed an excellent cathetometer, constructed by M. Perraux. The process thus combined enables us to obtain much greater precision than has hitherto been reached in this class of experiments. To judge of the degree of accuracy attainable, it suffices to examine the numerical details of two analyses; and it will be seen that the greatest difference between two analyses made with the same specimen of air never exceeded $\frac{1}{10,000}$th, and most frequently was not more than $\frac{1}{100,000}$th.

The various specimens of air which I analysed were collected in bulb tubes with the two ends drawn out and open; the capacity of these tubes was about 100 cub. centims. The air was collected in the following manner: one of the extremities of the tube was connected by means of caoutchouc tubing, with a little pair of bellows, which was moved sufficiently long to be certain that the whole of the air contained in the tube was replaced by the atmospheric air of the locality, taking the necessary precautions to avoid any mixture of the air of respiration; as soon as the air was collected the tubes were sealed before the lamp.

I have divided the analyses into three series: 1st, Analysis of the atmospheric air of France; 2d, Analysis of the atmospheric air of the Atlantic Ocean and Carribean Sea; 3d, Analysis of the air of New Granada.

The comparison of the results obtained in this investigation with previous ones shows that the constitution of the atmosphere is nearly the same in the New World and the Old World. Taking the mean of the analyses, executed in eleven different localities of New Granada, we find that 10,000 vols. of normal atmospheric air contain 4·008 carbonic acid, 2101·425 oxygen, and 7894·557 azote, which are nearly the same proportions as those which have been found for normal atmospheric air in various parts of Europe. However, on examining carefully all the experiments hitherto made on the constitution of the atmosphere, it is readily seen that the composition of the air is not absolutely constant. Perceptible differences exist, which vary with the meteorological conditions; thus after a long rain the carbonic acid and oxygen are always in smaller proportion than after a long drought; however, these differences are only appreciable when the analysis has been carried out with very great accuracy.

In the New World, where the seasons are more defined than in Europe, these variations are more easily detected. During the fine season the normal air always contains a little more oxygen and a little more carbonic acid than in the season of the rains. Thus taking the mean of a large number of analyses, I found that 10,000 vols. of normal atmospheric air of Bogota contain:

	During the rainy season.	During the fine season.
Carbonic acid,	3·822	4·573
Oxygen,	2099·542	2102·195
Azote,	7896·636	7893·232
Volumes,	10,000·000	10,000·000

The difference which exists between the atmospheric air of the two seasons is therefore on an average 0·751 for the carbonic acid, and 2·653 for the oxygen in 10,000 vols. of air.

Taking the maximum and minimum of the results obtained in the analyses performed during the two seasons, we have,

	During the rainy season.	During the fine season.
Carbonic acid, .	3·609	5·043
Oxygen, . .	2099·032	2103·199
Azote, . .	7897·359	7891·758
Volumes,	10,000·000	Volumes, 10,000·000

The greatest difference amounts consequently to 1·434 for the carbonic acid, and to 4·167 for the oxygen. These differences are nearly the same as those which I found between the atmospheric air of Paris and that of Havre, analysed under meteorological conditions corresponding to the two seasons of South America.

It follows that the composition of the air which we breathe is the same in Europe and in the New World as far as regards the oxygen and the azote, whether it be taken at the level of the sea, or at an elevation of 3000 metres; the only difference is the amount of carbonic acid, which appears, especially on the high mountains, to be somewhat greater than in the valleys, and on the sea-shore.

With respect to the analyses of the air collected on the ocean, they have yielded a very interesting result. In the day-time this air constantly contains a little more oxygen, and a little more carbonic acid, than during the night. This difference becomes more perceptible as we leave the coasts; and it is probably owing to the solar rays, which, heating the surface of the sea during the day, disengage a portion of the gases which the sea-water holds in solution, and which, as is well known, contains more oxygen and carbonic acid than atmospheric air.

Taking for term of comparison the specimens of atmospheric air collected on the Atlantic, on the same day, with the same wind, and at more than 400 leagues distant from land, we find :—

	At 3 A.M.	At 3 P.M.
Carbonic acid, .	3·346	5·420
Oxygen, . .	2,096·139	2,106·099
Azote, . .	7,900·515	7,888·481
	Volumes, 10,000·000	Volumes, 10,000·000

The difference is therefore 2·074 for the carbonic acid, and 9·960 for the oxygen in 10,000 volumes of air.

The analyses of the *abnormal* air of New Granada present us with results not less interesting. From time to time, once or twice in the year, the atmosphere of New Granada contains an extraordinary proportion of carbonic acid, which coincides with an appreciable decrease of oxygen; and, consequently, alters the constitution of the atmosphere in a very marked manner.

The great number of volcanoes which exist in the New World, and the clearing of forests which are effected every year in this country, may cause these alterations. It is, in fact, during these clearances that the constitution of the atmosphere experiences the extraordinary changes which I have just mentioned.

These clearings which are effected by vast conflagrations in the country *las quemas*, produce considerable quantities of carbonic acid, which, mixing with the atmosphere, alter its composition. The amount of carbonic acid which I found in this air, rose in some analyses to 49 in 10,000 volumes of air. It is consequently from 10 to 11 times greater than in the air in its normal condition. The diminution of oxygen amounted sometimes to 68·350 in 10,000 volumes of air; instead of 2101·425 oxygen, I found only 2033·075. This decrease is therefore readily detected even by less sensitive methods than the one which I employed.

On the other hand, the air of the table-land of Bogota sometimes presents an amount of carbonic acid far greater than the atmosphere of the *Tierra caliente*. This difference may be explained either by the existence of volcanoes, which are situated not far from Bogota, or by the more or less active influence of the solar light. It will be conceived, in fact, that in the *Tierra caliente*, where the temperature is very elevated, the decomposition of the carbonic acid by the green parts of the vegetables must be effected in a far more rapid manner than on the high table-land of Bogota, where the temperature is not higher than from 37° to 64° Fahr.

It is perhaps allowable to suppose, on observing this enormous quantity of carbonic acid appear from time to time in the atmosphere of the New World, and considering the large number of volcanoes which exist in the country, that a portion of the carbonic acid of the air is due to them, and that they thus contribute in part to nourish the vast and beautiful vegetation of the tropics.—*Comptes Rendus*, Sept. 29, 1851.

M. B. Lewy's *Expedition to New Granada.* 1. *Geology and Mineralogy, especially the remarkable discovery of the Geological Position of the Emeralds of Muzo.* 2. *New Animals and Plants of that Country.*

The accomplished naturalist and traveller M. B. Lewy, who left Europe in 1847 for the republic of New Granada, on a natural history expedition, has returned to Europe with rich and important collections illustrative of the geology, mineralogy, botany, and zoology of that interesting part of the New World. These collections have been deposited in the Museum of the Garden of Plants in Paris. The French Academy of Sciences appointed the following commissioners to report on the collections made in New Granada by Mr Lewy, viz., MM. Duméril, Isidore Geofroy-Saint-Hilaire, Ad. Brongniart, Elie de Beaumont, Dufrénoy, Milne Edwards, Valenciennes. This report contains many important facts, some of these we shall now mention.

Geology and Mineralogy.

The rocks and specimens of minerals deposited in the Museum of the Garden of Plants were collected by Mr Lewy in the valley of the Magdalena and the eastern Cordillera. The greater number of specimens are from the north side of that chain, and others from the south side, on which is situate, at a height of 2661 metres, Santa Fé de Bogota. Mr Lewy explored the mountainous regions to the north of that city, in the direction of Velez, de Tunja, de Muzo, &c. In ascending the course of the river Magdalena, he examined the alluvium of that river. Among the blocks rolled by the water of this river were masses of mica-slate, sienite, diorite, porphyry, sandstone, and varieties of black limestone. On the banks of the Magdalena, in other points of the valley, he observed a recent conglomerate, consolidated by a ferruginous base.

The table-land of Bogota and the mountains which vary its surface are formed of a very thick calcareous deposit, composed of numerous beds of red and white sandstone and schist, and of carburetted black limestones. These rocks had already attracted the attention of several observers, as Humboldt and Boussingault. More lately the Baron Gross observed and described with care the white sandstones which, in great masses, form the picturesque and singular escarpments of the Pont di Pandi, and also those from which is precipitated the celebrated waterfall of Tequendama.

The sandstones, whether red or white, contain no fossils, but such were found in several points in the beds of black limestone.

M. Lewy visited the fossiliferous localities where MM. Boussingault and Degenpart had already made collections which enjoy a just celebrity, and of which the species have been described by MM. de Buch and d'Orbigny. He has added many new species to those collected by his predecessors. We may mention *Crioceras Lewyanus*, Val. de Velez, one of the most beautiful which exists in any collection in Paris, and different species of Ammonites, d'Exogyres, of Trigonia, of Inocerama, &c.

Viewed in a general way, these fossils seem to confirm the conclusions which Buch and d'Orbigny have arrived at, by the study of the collections of MM. Boussingault and Degenpart, viz., that the great sedimentary table-land of Bogota corresponds to the lower cretaceous deposits of Europe, and particularly to that stage of those formations known under the name of *Terrain Neocomien.*

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Among a number of the more interesting observations of Mr Lewy, which are illustrated by the specimens in the museum, are those which refer to the celebrated emerald mine of Muzo.

The repositories of the emeralds are situate in the middle of a formation of black carburetted limestone. They are accompanied with crystals of calcareous spar and of paricite. As Mr Lewy collected in the same limestone of Muzo, and at a considerable depth, species of ammonite peculiar to the Neocomien series, he appears to have established the remarkable fact that the repository of the emeralds in Muzo is situate in *unaltered Neocomien deposits.*

Examined in a mineralogical point of view, the specimens consist of,—

1. Crystals of emerald and Paricite (carbonate of Lanthanium), from the mine of Muzo;
2. Native gold, from the mines of Antioquia;
3. Red silver and sulphuret of silver, from the mines of Santa Anna;
4. Fer oxydule, and iron pyrites, from Patcho;
5. Ores of copper, from Moniquira;
6. Different specimens of black compact limestone; many are crystalline and exhibit the lamellar texture.

The external characters of the last mentioned limestones do not enable us to judge of the period of their geological formation. But one of the specimens which contained crystals of sulphur, bore a strong resemblance to the limestone of Saliez in the Pyrenees, and that of Conil in Spain; both of which belong to the lower part of the cretaceous formations. The position of Palma from whence this limestone came, a little above Muzo, is in accordance with the presence of the crystals of sulphur, and which proves the identity of this crystalline limestone with the Neocomien series.

M. Dufrénoy, in studying on the beautiful map of New Granada, by Colonel De Costa, the position of the different minerals collected by Mr Lewy, concludes that these minerals form two distinct groups of formation, viz., 1. The black limestone of Muzo, the crystalline limestone of Palma, the schists of Moniquira, the pyrites of Velez, belonging to the vast limestone formation of the acclivities of the Cordilleras, and constituting the subrock of the valley of the Magdalena, are Neocomien. 2. The greater part of the metallic minerals, viz., the Galena of Ubate, the fer oxydule of Santa Rosa, the native gold and silver ore, appear to exist in a zone of the limestone, which marks the separation of Muzo and the crystalline rocks of the chain of the Cordilleras.

Zoology.

The collection of birds made at Santa Fé de Bogota is truly magnificent. It contains, at least, 285 species. The collection of Humming-birds is extremely beautiful. In the class of Reptiles there are many interesting specimens; and among these there is a large tortoise which forms a new species, named *Podocnemis Lewyanus*. Mr Lewy also brought from Magdalena two young Crocodiles of the species *Crocodilus acutus*, Cuv., which are thriving in the menagerie of the Garden of Plants.

Humboldt, in the Memoirs of the Institute for October 1806, gave an account of two remarkable fishes from the river of Bogota. One of them, known in the country under the name of Capitan, was distinguished by Cuvier as a new genus, which Humboldt named Eremophilus. Of this animal a number of specimens presented by Mr Lewy to the museum, will enable anatomists to give a detailed account of the anatomy of this animal. The second species, from Bogota, is a small fish called Guapucha, about which much uncertainty prevails; this will now be removed by the examination of many specimens presented to the museum by Mr Lewy.

The river Magdalena afforded many species of fishes, particularly of the Siluridæ. These are well represented in Mr Lewy's donation to the museum.

The collection of Insects made by Mr Lewy contains many interesting and important novelties: the collection of Shells and their animals is very instructive. The collection of Fossils from the Neocomien rocks of the table-land of Bogota, is valuable in a palæontological point of view.

Lastly, the collection of the Bones of Mastodons have settled many dubious points in the natural history of the species of that tribe.

Botany.

The collections of Plants, and their seeds and fruits, made by Mr Lewy, and the live plants brought by him to Europe promise to be of great importance. We may notice, among the vegetables of New Granada which of late years have attracted particular attention, the *Cedron*, a large tree growing in the warmer parts of the country. The grains of the Cedron contain an extremely bitter principle, which is employed with success as a very energetic febrifuge, and as an antidote against the bite of serpents. This plant appears to belong to the genus Simaba (*Simaba Cedron*, &c.)*

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* We find the following notice by M. B. Seemann, on the Simaba Cedron, in the Pharmaceutical Journal for December 1851:—"A tree, which has attained great celebrity, is that called Cedron (*Simaba Cedron*, Planch.) The most ancient record of it which I can find is in the *History of the Buccaneers*, an old work published in London in the year 1699. Its use, as an antidote for snakes, and place of growth, are there distinctly stated; but whether on the authority of the natives, or accidentally discovered by the pirates, does not appear. If the former was the case, they must have learned it while on some of their cruizes on the Magdalena, for, in the Isthmus, the very existence of the tree was unsuspected until about 1845, when Don Juan de Ansoatigui ascertained, by comparison, that the Cedron of Panama and Darien was identical with that of Carthagena. The virtues of its seeds, however, were known years ago from those fruits imported from the Magdalena, where, according to Mr Wm. Purdie, the plant grows in profusion about the village of San Pablo. In the Isthmus it is generally found on the outskirts of forests in almost every part of the country, but in greater abundance in Darien and Veraguas than in Panama. The natives hold it in high esteem, and always carry a piece of the seed about with them. When a person is bitten, a little mixed with water is applied to the wound, and about two grains scraped into brandy, or, in the absence of it, into water, is administered internally. By following this treatment, the bites of the most venomous snakes, scorpions, centipeds, and other noxious animals, have been unattended with dangerous consequences. Doses of it have also proved highly beneficial in cases of intermittent fever. The *Cedron* is a tree from twelve to sixteen feet high; its simple trunk is about six inches in diameter, and clothed on the top with long pinnated leaves, which give it the appearance of a palm. Its flowers are greenish, and the fruit resembles very much an unripe peach. Each seed, or cotyledon I should rather say, is sold in the chemist's shops in Panama for two or three reals (about 1s. or 1s. 6d. English), and sometimes a much larger price is given for them.

Mr Lewy, during his residence at Bogota, made many experiments with the grains of the Cedron, and brought with him not only specimens of the wood, the leaves, and the fruit of that tree, but also a young live specimen, which is expected to thrive in our conservatories, and may be distributed from thence to our colonies.

Lately, Mr Rayer has made a series of experiments with this bitter, which confirm the facts announced by Mr Lewy, as to the efficacy of the Cedron against intermittent fevers. We may add, that Mr Lewy did not neglect the study of Fossil Plants, as proved by the interesting collection of Fossil Plants, which he deposited in the Museum.

Of the Occurrence of the Remains of the Rein-deer in Scotland. By JOHN SCOULER, M.D., F.L.S. Communicated by the Author.*

It is remarkable, that although remains of the rein-deer have been found in the south of England, and that even so late as the time of Julius Cæsar, this animal lived in the north of Germany, no authentic evidence of its former existence in Scotland has yet been recorded. The late ingenious Dr Hibbert attempted to prove, that even down to the twelfth century wild rein-deer were found in Caithness, where they were hunted by the Norwegian chiefs. The quotations which he gives from the northern chronicles although plausible, will scarcely be esteemed conclusive, especially as no bones or horns of the rein-deer have hitherto been found in Caithness or Sutherland.† The rarity of the remains of the rein-deer in Scotland, is probably more apparent than real, for the bones found in bogs and marl are but little attended to, unless remarkable for magnitude; and fragments of horns will be referred to the red-deer, or fallow-deer, according to their form, whether round or palmated.

The fragments which I have to notice were found several years ago (1833) in the alluvium of the Clyde, on the north side of the river below its junction with the Kelvin. This alluvial matter consists chiefly of finely laminated sand, of which sections are disclosed by the operations now in progress for improving the navigation of the river. It was in the alluvial matter thus exposed, that the remains were found, and but for the attention of Mr Smith, of Jordan Hill, would have been thrown aside and forgotten, as has no doubt been the fate of many equally interesting relics. The remains consisted of a cranium of the extinct Ox, *Bos primigenius*, along with a number of fragments of deer's horns, most of them so imperfect, that it was difficult to decide whether they should be referred to the red-deer or the rein-deer. The imperfect fragments were smooth, and somewhat compressed, circumstances which afforded a presumption that they did not belong to the red-deer, but fortunately there was among them an antler, which removed all ambiguity. This fragment was 3 inches in breadth and 10 in length, and corresponded precisely to the brow-antler of a fine head of the rein-deer, preserved in the Andersonian Museum. This portion was flat and smooth, as in the rein-deer, and terminated in three distinct digitations precisely as in the recent specimen in the Museum.

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* Read before the Natural History Society of Glasgow, 2d December 1851.

† Hibbert, Edinburgh Journal of Science, vol. v., p. 50.

It has already been stated that these fragments were found in the river alluvium, associated with the cranium of the *Bos primigenius*. Whether they were contemporary with man is an interesting question. In Denmark such topics have excited much interest, and given rise to some very curious investigations. In that country the remains of the rein-deer and the *Bos Urus* are found associated with flint arrow heads, stone hatchets, charcoal, and other relicts of man, but no such direct evidence is to be obtained in the present case.* It is, however, certain that remains of human art, of equal if not greater antiquity, are to be found in the same alluvial deposits, as that in which the remains of the rein-deer were found. In the year 1848, four canoes were found at Springfield, and all of them within a few yards of each other. These canoes were covered by a deposit of 17 feet of finely laminated sand. In other cases canoes have been found in the same alluvium, but much farther inland or remote from the modern channel of the river, as at London Street, and under the site of St Enoch's Church, and in the two last quoted instances the canoes are probably of greater antiquity than the remains we have described.

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* Undersögelser i geologisk-antiquarisk Retning af Forchhammer. Steinstruap og Worsaae. Kopenhagen, 1851. These interesting geologico-antiquarian researches form a short memoir of 57 pages, and their translation would confer a favour on the English reader.

On certain New Applications of Prisms. By the Rev. W. Hodgson, Old Brathay, Ambleside. With a Plate. Communicated by the Author.

It has long been well known that when objects are viewed by means of pencils of light, which are refracted through an isosceles prism, and suffer an internal reflexion at the base, the objects are seen quite free from chromatic dispersion. Little attention however seems to have been paid to the fact that there is a position in which the pencils of light, after being thus refracted and reflected, may be made to enter the eye along with other pencils proceeding directly from the object. The position referred to is that represented in figure 1. If P Q and P E be contiguous rays of a parallel pencil proceeding from a distant object, one ray will follow the course P Q R S E, while the other will pass directly from P to E. In this position the image and the object coincide exactly; but if there is the slightest deviation from this position on either side, then the object and the image may be seen separately.

The application of this principle to the measurement of angles is easy and obvious. For this purpose the prism merely requires mounting, with its axis perpendicular to a movable graduated circle, which is capable of being adjusted at any required inclination to the horizon.

The form of prism best adapted for an instrument of this description seems to be one of which the principal section is an equilateral triangle. For as an observation can be taken in the direction A C as well as in the direction C A (fig. 1), and as each face of the prism may be used in succession, there are altogether six observations so arranged that their errors will correct each other. Figs. 2 and 3 are rough sketches copied from an instrument fitted for observing *any* horizontal angles and *some* altitudes. The table for supporting the prism and its frame consists of a stout square brass plate, adjusted for parallelism to the horizon by the two spirit levels A A, and by the three screws B B, of which two only are shewn in the figures. The upper surface of the table of the instrument is graduated; and the frame which contains the prism is clamped by a screw to the movable circle which carries the verniers. With this arrangement the horizontal angle between two objects is readily found. It is not material that the objects should be nearly at the same height above the horizon; for the only effect of viewing an object obliquely, instead of directly through the prism, is a very slight displacement in a vertical plane, which does not interfere with the horizontal angle.

In fig. 3 the back of the same instrument is shewn in a state adapted for finding the time, &c., by the method of equal altitudes. On the face of the movable circle already referred to, there are two small holes to receive the points G G, by which the axis of the prism is kept parallel to the plane of the table. The screw C C which passes through the nut D, gives the power of raising or depressing that face of the prism through which the observation is being taken. The nut D is movable upon its axis, and the point F of the screw C C, may be inserted successively into the several holes which are prepared for it. By this means any required number of altitudes may be taken, and as these can be all repeated in the reverse order, these will be the pairs of observations which are necessary.

If the actual altitude in any case is desired instead of the mere fact of there being pairs of equal altitudes, this may be obtained by a slight modification of the instrument. Let the nut D be rigidly fixed so that the axis of the screw C C shall be perpendicular to the face of the prism used in taking the observation. Then the tangent of the altitude to the constant radius G F is given by the variable portion D F of the screw below the nut D.

If the table of the instrument (fig. 2) be permanently fixed in a position parallel to the plane of the equator, and if the degree and minute on the graduated circle, correspondent with each face of the prism coinciding with the meridian be observed and registered, the true time may be found within a second or two at any period during the day when the sun is visible, or during the night from observations of known stars of the first, second, or even third magnitude.

If the instrument be placed with its table horizontal, the observations would give azimuths instead of hour angles. Or, suppressing the graduated circle, and fixing the prism with one of its faces parallel to the meridian, and its axis perpendicular either to the horizon or to the equator, there will be six known directions in which the transits of the heavenly bodies may be accurately determined.

The rectangular isosceles prism is capable of being employed in this instrument; and in the course of investigating its advantages, some uses of a prism of that form were suggested which appear hitherto to have passed unnoticed.

In Coddington's Reflexion and Refraction, and possibly in some earlier optical works, it is stated that a feeble but very distinct second internal reflexion may take place in a triangular prism, when one angle is a right angle, and the other two each half a right angle. It is not, however, stated that the feebleness of this image may be remedied by silvering the base of the prism. If this plan be adopted, the rectangular prism becomes at once a camera lucida. Fig. 4 shews the course of the ray in this case, and it is obvious from fig. 5 that there is another, though for some purposes less convenient direction in which the prism will serve the purpose of the camera lucida. There is also this advantage in the rectangular prism, that if it is desired to take a reversed copy of the object, this is given by the single internal reflexion, and either may be taken at pleasure.

In this, and in Dr Wollaston's camera, the incident and the emergent rays are accurately perpendicular to each other, and it is somewhat strange that a little instrument termed an optical square should have been introduced, when the purpose for which it was constructed is answered either by the camera lucida or by the rectangular prism.

There remains still one other application of the rectangular prism, which is too important to be overlooked. If a prism of this form be placed over the eye-piece of a compound microscope, or of an astronomical telescope,* so that its axis is inclined to that of the microscope or telescope at an angle of 45°, the rays, after suffering two internal reflexions, will emerge without chromatic dispersion, and in such a manner as to do away entirely with the inversion produced by those instruments. There is, however, a great loss of light, in consequence of the obliquity at which the rays enter the prism. With a view to remedy this defect, various plans were tried. Two equilateral prisms cemented together, with their axes perpendicular to each other, were found to erect the image without loss of light, and to allow of its being seen as if projected on a screen placed to receive it: but there was a deviation to the right or to the left, which was unsatisfactory. The regular tetrahedron also was tried, and after trial rejected for a similar reason. At length the solid represented in fig. 6 was adopted, and found to answer completely. The rays are incident upon the first surface perpendicularly, the internal reflexions are both total, the solid is of a form which admits of easy adaptation to the eye-pieces, the movements of the image correspond exactly with those of the object, and the image may be traced upon a screen placed behind it, as readily as with the camera lucida. The lower surface might, if necessary, be ground into the form of a lens, but this, on other accounts, is inconvenient.

OLD BRATHAY, 13*th November* 1851.

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* It is not anticipated that this mode of erecting the image will be generally used by astronomers; but the addition of such an appendage to the eye-piece of an astronomical telescope of low power forms an *improved graphic telescope*, which may be serviceable to draughtsmen.

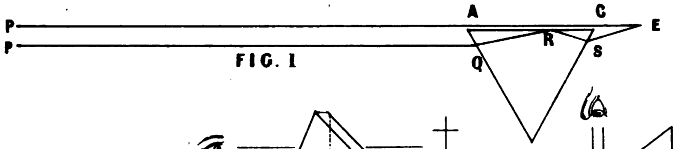

FIG. 1

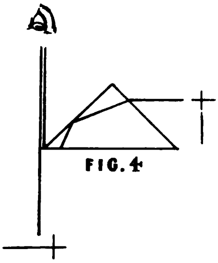

FIG. 4

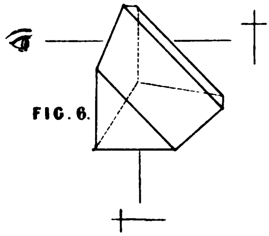

FIG. 6.

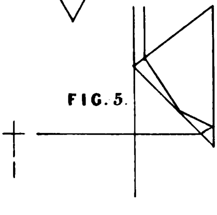

FIG. 5.

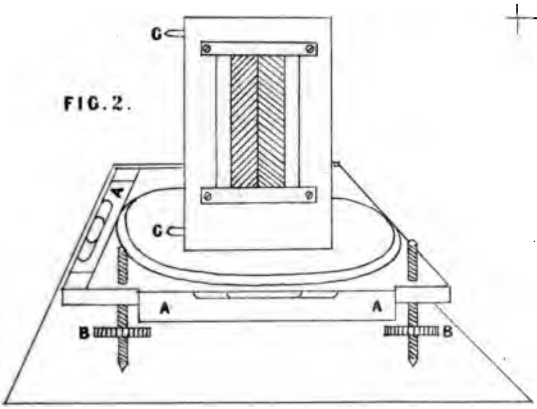

FIG. 2.

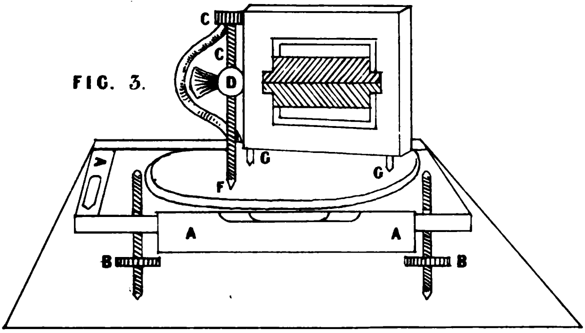

FIG. 3.

HODGSON'S NEW APPLICATION OF PRISMS.

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Geological Notes. By Professor SILLIMAN, Junr.

Professor Silliman, junr., during his late visit to Europe, examined many interesting geological localities, of which he gives short notices in his Journal. Some of these we now lay before our readers.

1. *Grotto del Cane and Lake Agnano.*

The Grotto del Cane, or dog grotto, has been so much cited for its stratum of carbonic acid gas covering the floor, that all geological travellers who visit Naples feel an interest in seeing it. Unfortunately, like some other grottos, its enchantment disappears on a near view. It is a little hole dug artificially into the foot of a hill facing Lake Agnano. The aperture is closed by a door, and the space within is barely sufficient for one person to stand erect. Into this narrow cell a poor little dog is very unwillingly dragged and placed in a depression of the floor, where he is soon narcotized by the carbonic acid. The earth is warm to the hand, and the volume of gas given out is very constant.

Lake Agnano, as is well known, fills the bottom of an ancient crater whose walls are still to be distinctly traced. On the shore of the lake immediately opposite the Grotto del Cane, there is a constant and copious discharge of carbonic acid, and the water of the lake at that part is in great agitation from its escape. Nor is other evidence wanting of the present operation of the ancient causes which have characterised this region. At the foot of the hill, on the east, are numerous vents of steam and sulphur. Over some of these vapour baths (Sudatoriæ) have been established, which are held in some repute in cases of rheumatism. Digging a short distance into the hill, near the ruins of the villa of Lucullus, it is easy to perceive the presence of volcanic energy in the hot vapours, accompanied with sulphur, which issue copiously from the surface. The villa of Lucullus was entirely buried in lapilli and volcanic ashes, proceeding, as is supposed, from a vent in the immediate neighbourhood; but from which vent does not appear—evidently not from the one now containing Lake Agnano, since that has not been active in the historic period.

In another cavity excavated in the hill, near to the Grotto del Cane, is an abundant flow of carbonic acid, accompanied, as is said, by ammonia; but we did not perceive any odour of this gas, nor any deposit of carbonate of ammonia or of sal ammoniac on the walls of the place.

2. *Sulphur Lake of the Campagna, near Tivoli.*

The celebrated sulphur lake of the Campagna, near Tivoli, the Aquæ Albulæ of the ancients, still retains its interest to the geologist, as the most remarkable of all the thermal sources of Italy. Whether we regard the constancy of the flow from it, both of water and of gas, the area of the lake, or the important part which it and similar craters appear to have played in the formation of the travertine of the Campagna—we must admit that it is worthy of attentive consideration.

In the days of Father Kircher, this lake was described as being over one mile in circuit. Now, the lake is not over 500 or 600 feet in diameter, and its area is constantly diminishing. The baths of Agrippa, which are now at a short distance from the shore, shew the extent to which this contraction has taken place in that direction, since they were erected in the waters of the lake, which were much esteemed by the ancient Romans for their hygienic effects. These baths were frequented by Augustus, and enlarged by Zenobia; the latter spent her Roman servitude in Tivoli; and in allusion to this, they are still called "*Bagni della Regina.*" At present, the waters are conducted from this lake by a canal artificially cut in the travertine by Cardinal Ippolito d'Este, former Governor of Tivoli, for a distance of two miles. This canal is nine feet wide and four feet deep, and there is a constant discharge of the surplus waters through it in a very rapid current, the volume of which is remarkable when we notice the small size of the source.

The strong odour of sulphuretted hydrogen announces the existence of lake a long time before the traveller reaches it. The w vas examined by Sir Humphrey Davy, who found it to contain one volume of carbonic acid, and less than a half volume of sulphuretted hydrogen. Tracing the canal from where it escapes, the "Via Appia Nova," up to the lake, a mile and a quarter, the observer is much struck with the copious escape of large volumes of gas from the whole surface of the lake, which is such as to convey the idea of ebullition. A stone cast into the water is soon followed by a very violent escape of gas, causing the whole adjoining area to boil with great energy, and a loud sound of effervescence. The water is very clear, a slight milky, or opaline appearance it has, being due, as we thought, to the reflection of the white sides and bottom of the lake. Its temperature is 80° F., and it has, when drunk from a glass, an agreeable pungent taste of free carbonic acid, with no more of sulphuretted hydrogen than is pleasant. It is perfectly clear in the glass, and effervesces briskly. The escape of the gas does not appear to be confined to any particular part of the bed of the lake, but takes place equally over all its surface. The grass and reeds which grow luxuriantly at its margin, are constantly encrusted with carbonate of lime from the water, and it is from this cause that the area of the lake appears to have been contracted, and not from any partial drainage, which is evidently inexplicable, since the level of the lake is now only a few inches below that of the adjoining and level Campagna. Breaking off a mass and clods from the shore, it was found that the roots of the plants were also encased; while the stone walls of the fields adjoining were wholly composed of loose blocks of travertine, made up entirely of casts of the stems of growing grapes and aquatic plants. It required but casual observation of the travertine in other and distant parts of the Campagna, to detect the same species of plants imbedded in every part of its mass. Blocks of travertine in the Colosseum at Rome and other ancient buildings, also shewed us the same evidence. A large space on the Campagna, near the sulphur lakes, lately fell in, owing to the cavernous and unsupported nature of the rock; and it was easy to see, in the freshly fractured portions of the rock, the same stems of aquatic plants, such as now grow on the margin of the water.

It is perhaps too much to infer from these casual observations so wide a deduction as that all the travertine is due to this origin from sulphur waters charged with bicarbonate of lime; but it is not going further than is allowed by a prudent philosophy, to say that travertine is now forming on the shores of Lake Solfaterra from this cause.

3. *Present Condition of Vesuvius.*

The eruption of Vesuvius in February 1850, and that of the year previous, entirely changed the summit features of this ancient mountain of fire. The former crater disappeared, being filled with scoria and ashes, while *two* craters now occupy the summit of the cone. The deepest and most active of these is that of February 1850, which is situate on the side of the cone nearest to Pompeii. It is somewhat lower, and has a much greater depth than its immediate neighbour, which is on the side of the bay of Naples. We had no means of measuring its depth accurately, but judging from the time required for the returning sound of a stone cast into its mouth, as well as from inspection and comparison, we assumed the depth of the new crater to be from 800 to 1000 feet. It is acutely funnel-shaped at an angle of not less than 60°. It is impossible, because of the stream and vapour of sulphurous acid, to see its bottom, even if not prevented by the danger of the descent to a position where one might hope to catch a glimpse of its bottom. Its activity at present is confined to the emission of vapour, and even this seems at times, when viewed from the sea, to be wanting. On the summit, however, these vapours appear dense enough, and are sufficient to prevent the possibility of making the entire circuit of the crater. From this cause we were unable to examine the lip dividing the crater of 1850 from its neighbour. The observer is much struck, not only with the change of form in the summit, as shewn by the drawings of Professor Scacchi, but also with the sharpness of the lip of both craters, which is such that it is hardly possible for more than two persons to stand abreast upon it. During the late eruption, the lava found vent from the base of the cone on a level with the sand plain which fills the ancient crater of

Somma. It here poured out a torrent of scoriaceous red lava through a well-defined canal. This is now entirely cold, and we collected from its sides abundant specimens of aphthitalite, which frosted over the rugged cavern like snow. Near this spot also are two fumeroles formed during the last eruption; the largest about 25 feet high, with an aperture of near ten feet, its outer walls black, rugged, and forbidding. The flow of lava from the eruption of 1849 was in the direction of the ancient Pompeii, and it was copious enough to destroy a small village with its vineyards, at the distance of several miles. The king of Naples has since erected a new village for the unfortunate inhabitants near the site of the former one.

During the past six years the king of Naples has also constructed a carriage road up the side of Vesuvius as far as the Hermitage, where he has a Royal Meteorological Observatory, under the direction of the celebrated Melloni. This road follows in a very serpentine path over and around the hill of ashes, which all who have seen Vesuvius will remember as forming a remarkable feature in its topography. In this manner, sections have been opened in the hill for a distance of three or four miles, and were these viewed without reference to the immediate proximity of the volcano which has produced the deposit, it would be easy to refer the whole to an alluvial origin, so characteristic are the undulating lines of deposition, the alternation of coarse and fine materials interstratified, including now large angular masses of rock, and again graduating into the finest silt and mud. In some places the lines of deposition are curved in regular undulations, and in others they meet at a sharp unconformable angle. Close observation alone detects that the whole material is volcanic—pumice, scoria, sand, and fine dust, including large blocks of inflated lava and tufa.

It is impossible to see any difference in the general character of these deposits and of those which cover Pompeii, only that the latter being mostly the result of one eruption are less varied than the former, and more regularly stratified. In both, the evidence of the aqueous action is very obvious; and we have historical as well as geological evidence of the eruption of vast volumes of aqueous vapour with the lapilli, scoria, and fine ashes from Vesuvius, which, condensing into rain, produced a deluge of hot mud, filling the most intricate recesses of the Pompeian houses, and producing the appearance of an aqueous deposit in the ash hills of the flanks of Vesuvius. In Herculaneum we see the same phenomena in a more remarkable manner. Here, owing to a much longer accumulation of material—to subsequent overflows of lava, and the superincumbent weight thus produced, with the aid of water, the ashes were consolidated into so compact a mass that some writers have even doubted whether Herculaneum had not been destroyed by an overflow of lava in the first instance. That such was not the fact is well known, and the condition of the antiquities imbedded there quite forbid the idea, were no other evidence attainable.

4. *Meteorological Observatory of Mount Vesuvius.*

The Meteorological Observatory recently erected at Mount Vesuvius, was projected by Professor Melloni, so well known to all the world by his memorable researches on heat, and the most distinguished of all the Italian physicists. The King of Naples gave the enterprise his sanction, and furnished the means to construct the building. The house is of ample dimensions, standing on an artificial terrace at the summit of the hill of ashes, which forms the limit of the arable region of Vesuvius, and at an elevation of about 2000 feet. The centre has three floors above the basement, and the two wings, each one floor above the basement; in the rear, and joining the main building, is a round tower, and the roofs are conveniently arranged for meteorological purposes. All the plans were furnished by Professor Melloni, who also superintended its erection, which, by an inscription on the exterior, appears to have been begun in 1841.

Unfortunately for science, the revolution of 1848 entirely arrested the farther progress of the undertaking; the house stands vacant, no instruments are provided, and, worst of all, Professor Melloni has been removed, not only from his direction in the Observatory, but also from his Professorship in the University, under the caprice of a despot who knows no law but his own will, and who has shewn in this act that he was unworthy of so noble a subject.

5. *Fish of Mont Bolca.*

At Padua we found the most complete collection of the fossil fish of Mont Bolca, probably in the world; over 500 specimens, generally presenting both sides, some of them five or six feet long, and all remarkably perfect. We visited this celebrated locality last Friday. It is in a very wild and romantic region, surrounded by lofty mountains. Mont Bolca itself is 2000 feet high; and to the north and east the Tyrolese Alps rise abruptly, leaving a profound and steep valley between them and the base of Bolca. Columnar basalt in regular forms crowns the summit, and intrudes between the vertical fish-beds.

6. *Mineralogical Notes.*

Sacacchite is a silicate of lime and alumina, containing fluorine, and occurs in square prisms highly modified.

Leucite occurs at Vesuvius in the older ejected blocks, as well as the most recent lavas, and it is observed in some instances undergoing a change to Ryacolite, while still retaining the external form of leucite, and sometimes cavities of ryacolite crystals are formed in the leucite.

Zircon occurs at Vesuvius in beautiful white and blue octahedrons in the old ryacolite gangue. *Fluor spar* occurs in octahedrons with hornblende in the older lavas.

Forsterite is identical with anorthite.

Davyne is regarded by Professor Sacacchi as a variety of *Nepheline.* The six-sided prisms are striated longitudinally, and are modified by a plane on the terminal edges, and another on the lateral; it occurs in a compact pyroxenite gangue, while the nepheline occurs in a gangue of ryacolite.

Arragonite is formed in an old mine at Monte Vasa from day to day, at a temperature below that of boiling water.

Buratite comes from Campiglia in the Maremma Pisena in Tuscany, and not from Volterra.

Tourmalines of Elba. In the Grand Duke's collection at Florence there is a specimen 11 inches square, with four erect green tourmalines and one prostrate, 2, 4, and 2½ inches long, and ¾ to 1 inch thick. They are associated with orthoclase and crystallized quartz. The pink tourmalines of Elba have always the basal plane OR, while the green prisms are terminated with rhombohedral planes.

Analcime? A singular analcime-like mineral occurs at Monte Catini, in which the soda replaces the magnesia, according to Professor Moneghini of Florence, who obtained for its composition—

$\dddot{Si}$	$\dddot{Al}$	$\dot{Mg}$	$\dot{Na}$	$\dot{K}$	$\dot{H}$
59·347	22·083	10·250	0·450	0·015	7·560

[This result give the oxygen ratio for the protoxids, peroxids, silica, and water 1 : 2 : 6: $1\frac{1}{3}$.]

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Observations on the Zodiacal Light; with an Inquiry into its Nature and Constitution, and its Relations to the Solar System.

By DENISON OLMSTED, Professor of Natural Philosophy and Astronomy in Yale College.* With a Plate. Read before the American Association for the Advancement of Science, at the Annual Meeting at Albany, August 1851.

I submit to the Association a series of observations on the Zodiacal Light, made by me at Yale College from 1833 to 1839, upon the basis of which I propose to offer a new description of this mysterious phenomenon, and a brief inquiry into its nature and constitution, and its relation to the solar system Particularly, I propose to inquire whether or not it is the origin of the meteoric showers of November and August.

Various circumstances conspire to interrupt the continuity ber. At the conclusion of the essay, I suggested the possibility that the zodiacal light might be the body in question. I was reluctant, however, to insist on such a connection, because the existence of the nebulous body was inferred from evidence wholly independent of the zodiacal light, and even before the zodiacal light was thought of. In fact, at that time, I had very vague ideas respecting this light, as something that appears in the west after twilight about the time of the vernal equinox; but I did not even know that it was ever visible at the period of the year when the November meteors occurred; for, at that time, I had never read either the observations of Cassini on this body, or the treatise of Mairan on the Aurora Borealis, where so much is ascribed to its agency in the production of this latter phenomenon. Nearly twenty years have since elapsed, and I have had sufficient opportunity to observe the zodiacal light, and to reflect on the question of its possible connection with the meteoric showers of November and August. The result is, an increasing conviction of such a connection. I may here remark, that the first idea of such an origin of the November meteors is now generally ascribed by European writers to M. Biot. It may be proper, however, to state, that the paper in which M. Biot first mentions the subject, is an essay read before the French Academy, soon after the meteoric shower of November 1836, three years after my paper was published. M. Biot does, indeed, favour the idea that these showers of meteors have their origin in the zodiacal light; but in noticing the views which I had published respecting the cause of the meteoric shower, which he did me the honour to review at some length, and in a manner very encouraging to myself, he distinctly stated that I had in my paper suggested the idea that the zodiacal light might possibly be the very nebulous body in question.

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* In next number of this Journal a particular account of the Zodiacal Light as seen in Southern Africa will be given.

I am aware that the opinions I have formed differ widely from those entertained by many members of this Association, whose eminent talents and great success in the investigation of truth entitle them to the highest deference; but, should I fail of convincing them of the correctness of my views, I still indulge the hope that I may secure increased attention to a natural phenomenon, which appears to me to have important relations to our solar system, as well as to several of the most sublime and mysterious phenomena of nature.

In the paper which I published in the American Journal of Science in the year 1834, on the cause of the great meteoric shower of November 13, 1833, I inferred the existence, in the planetary spaces, of a nebulous body revolving around the sun, the extreme portions of which, on the 13th of November, lay over or across the earth's orbit, in such a manner that the earth passed through it, or at least near enough to it to attract portions of it into its atmosphere, where they took fire and exhibited the phenomena of shooting stars. As the leading steps by which I arrived at this conclusion, after an extensive induction of facts, were very brief and simple, I may be permitted to repeat them here. I argued thus: If all the meteors which fell on this occasion (which were in vast numbers, and some of them proved to be bodies of comparatively large size), had been restored to their original position in space, they would of themselves have composed a nebulous body of considerable extent. But since the same shower had been several times repeated without any apparent exhaustion of the nebulous body, it was inferred that only small portions of that body came down to us, such as constituted its extreme parts which approximated nearest to the earth; and various reasons induced the belief that the nebulous body itself was one of very great extent. It was a striking fact that the earth had, during several preceding years, fallen in with this body at exactly the same part of its orbit. Now, since it is impossible to suppose that a body thus situated, and consequently subject to the sun's attraction, could have remained at rest in that part of the earth's orbit while the earth was making its revolution around the sun, the conclusion was that the nebulous body itself has a revolution around the sun, and a period of its own. Since the earth and the body met for several successive years at the same point of the ecliptic, that period must obviously be either a year or less than a year. It could not be more than a year, for, in that case, the body would not have completed its *revolution* so as to meet the earth at the same point for successive years. Its period might be a year, and it might be less than a year, provided the time was some aliquot part of a year, so as to make it revolve just twice or three times, &c., while the earth revolves once. The time being given we easily find the major axis of the orbit by Kepler's third law. On trying so short a period as one-third of a year, it gives a major axis too short to reach from the sun to the earth, and hence it was inferred that the body could not have so short a period as four months, since it would never in that case reach the earth's orbit, even at its aphelion. A period of six months was found to be sufficient, and this was accordingly assumed at first to be the time, although the possibility that the period might be a year was distinctly admitted. But, extensive as I even then believed the nebulous body to be, I had formed very inadequate notions of its real extent, for this may clearly be sufficient to reach from the sun to the earth, and thus to correspond in dimensions to the zodiacal light; and since the centre of gravity of this body may be far within the earth's orbit, so its orbit may, even at its aphelion, be distant from the earth, and yet the extreme portions of the body may reach beyond the ecliptic. It would, therefore, be entirely consistent with my original views, to assign to a nebulous body of such an extent as that of the zodiacal light, a period as short as one-third of a year or even less.

I do not assert positively that the zodiacal light is the veritable body which produces the meteoric showers of November and August. Before such an hypothesis can be proved to be true or false, with certainty, a greater number of precise observations, continued through a series of years, would require to be made, and a careful comparison instituted between the hypothesis and the facts. Should the zodiacal light be found at last incompetent to explain the periodical meteors, the existence of a nebulous body, as inferred from a full survey of the facts in the case of the meteoric shower of November 13, 1833, independently of all hypothesis, will still be true. But, with great deference, I submit to the Association the following *presumptions* in favour of the opinion that the zodiacal light is the nebulous body which produces the meteoric showers of November.

1. The zodiacal light, as we have found in our inquiry into its nature and constitution, is a *nebulous body.*

2. It has a *revolution* around the sun.

3. It reaches beyond and *lies over the earth's orbit* at the time of the November meteors, and makes but a small angle with the ecliptic.

4. Like the "nebulous body," its periodic time is *commensurable* with that of the earth, so as to perform a certain whole number of revolutions while the earth performs one, and thus to complete the cycle in one year, at the end of which the zodiacal light and the earth return to the same relative position in space. This necessarily follows from the fact, that at the same season of the year it occupies the same position one year with another, and the same now as when Cassini made his observations nearly 170 years ago.*

5. In the meteoric showers of November, the *meteors are actually seen to come from the extreme portions of the zodiacal light*, or rather a little beyond the visible portions; and the same was true of the radiant point of the meteors (when watched as it was by Mr Fitch,† from October 16 to November 13, 1837), namely, that the radiant always keeps the same relative position with respect to the vertex of the zodiacal light, being with that vertex in Gemini, in the month of October, and travelling along with it through the constellation Cancer, and into Leo, where it was on the morning of the meteoric shower. Observations, so far as they have been made, indicate a similar relation between the meteors of August and the extreme portions of the zodiacal light.

These five propositions I offer as so many facts established by observation. Most of them appear in the original paper of Cassini on the zodiacal light; others may be seen in the tabular collection by Houzeau of all the known observations made at different periods; a few, not noted by others, have been added by myself. For the inferences here made respecting the connection of this body with the periodical meteors, I alone am responsible.

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* For the first suggestion of this analogy, I am indebted to one of my former pupils, Mr Hubert Newton.

† Amer. Jour. Sci., xxxiii., 386.

Concerning the Successive Appearance and Disappearance of Great Glaciers upon the present surface of the Terrestrial Globe. Extract of a Letter from M. A. DE LA RIVE to M. ARAGO.

The communications which M. Constant Prevost has presented to the *Académie des Sciences,* upon the appearance, the diminution, and the disappearance, of glaciers, have recalled to my recollection that, in the year 1845, I ventured to express an opinion on the subject, which, to a great extent, corresponds with that of M. Prevost. The occasion was presented in the course of the discussion elicited by the researches of M. Agassiz, concerning the origin of boulders, which the learned geologist communicated to the Helvetic Society of Natural History, during its meeting at Geneva. The notice of M. Prevost has afresh excited my attention to this question of glaciers, and I flatter myself that I have succeeded in elucidating it in a satisfactory manner, so perfecting those ideas which I had only orally announced in 1845. The following is a sketch of them:—

Along with M. Prevost, I do not think it at all necessary to inquire elsewhere than in present existing causes for the explanation of the successive appearance and disappearance of great glaciers upon the existing surface of our globe. I am satisfied with starting from a fact which is not only in harmony with the best established theories of physical science, but which, moreover, is confirmed by direct observations, and which may be thus expressed,—That in mountainous countries especially, humidity is accompanied, at all times, by a very decided diminution of temperature. To which is to be added, that when the emersion of the European soil was effected, the strata of the most recent formation, still anterior however to the appearance of the glaciers, must needs have been impregnated with a considerable quantity of water, since previously they had always been submerged. Great evaporation then would necessarily be the consequence, whence would result vast downpours of rain, and consequently a considerable fall of temperature. These two causes united,—on the one hand, producing a greater quantity of water than now actually falls in the form of snow upon the high mountains, and on the other, a smaller quantity than at present of the snow melting by the action of the solar and the terrestrial heat,—would necessarily produce an amount of ice more considerable than that which constitutes our existing glaciers, and consequently would enormously augment their actual extent.

Moreover, direct experiment has convinced me that the cold produced by evaporation is more intense where the water, which is undergoing the process instead of forming a surface perfectly liquid and uniform, is commixed with substances which it holds in suspension, or between whose particles it is lodged;* a phenomenon which is produced by many causes, and which has relation to the influence which the presence of certain substances in the water exercises upon the temperature of its ebullition,—its boiling point,—and in diminishing cohesion. Hence it results that the cold proceeding from the evaporation effected upon the surface of uprisen humid deposits, was much greater than that which the same evaporation produced when the water entirely covered the surface.

I may now direct attention to a particular observation which substantiates what I have said above concerning the influence which prolonged humidity, and the cold thereby resulting, exercises upon the extent of glaciers. In the year 1815, Professor Pictet ascertained, by precise measurement, the horizontal distance of some of the prominent points of the base of the glacier of the *Bosson de Chamouni* from certain other fixed points, which were marked by enormous blocks of granite forced into the soil of the lower ground, towards which the glacier seemed to be advancing. At the close of the year 1816, the glacier had advanced in all directions, and in particular not less than 50 feet towards one of the marks; and, at the close of the year 1817, all the marks had disappeared under the glacier. Another glacier, that *des*

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* The cold produced by the *alcarazas* cannot be accounted for, solely from the greater surface presented to the water which is evaporated. There is in this phenomenon a cause analogous to that which makes moist sand refrigerate more under the process of evaporation than pure water.

Bois, had risen laterally against a neighbouring mountain, designated the *Chapeau*, which it enclosed on its northern aspect, threatening to make inaccessible a spot which is often visited by the curious traveller who visits Chamouni. During the spring of the year 1818, although the winter had been much more mild than severe, the glaciers had not ceased to advance, especially at their lower portions, in a way which alarmed the occupiers of the nearest dwellings; and this phenomenon occurred also at the glaciers both of the Tyrol and at those of Chamouni. Far, however, from continuing their progressive advance, in the following year, all these glaciers, after having undergone a process of arrest, actually retrograded to an extent which could not be mistaken, and resumed their ordinary dimensions, at all points; as prolonged observation teaches us to expect. The extension and the succeeding retreat depended upon this,—that the years 1816 and 1817, after having been extraordinary years, in respect of the enormous quantity of rain and snow which fell, had been followed by seasons which were rather dry than wet, or which, at least, were below the average, as to the quantity of rain. And, if the occurrence of two consecutive years more humid than ordinary sufficed to produce such a vast increase of the existing glaciers, it is not difficult to comprehend, that if a certain number of similar years had succeeded each other without interruption, then the glaciers of Chamouni, filling up the valley of the Arve, would have advanced, and finally would have penetrated to the valley of the Rhone. In fact, in circumstances analogous to those which produced the two consecutive years of 1816 and 1817, all we may say that is desiderated, so far as the mountains which produced them are concerned, is, that winters should regularly succeed each other, and without intermediate summers; this result then would follow, that the accumulations of snow would soon become so enormous as to produce a most rapid progressive advance of glaciers descending from their summits.

After having thus explained the appearance and production of great glaciers, let us now consider how we may account for their disappearance. At the first glance it appears that the enormous humidity which had accompanied the emersion of the formations which most recently appeared, should unceasingly perpetuate itself, evaporation being insufficient to disperse it, inasmuch as it would in its turn produce as much more rain as it, the humidity, was itself considerable; and since, moreover, the winds could not in this matter change the condition of the atmosphere, seeing that the humidity alike prevailed throughout. It results, then, as a necessary consequence, that ere the conditions in which the vast amount of ice has been produced undergoes any modification, a certain absolute quantity of meteorological water should disappear. Well, then, it is not difficult to discover in a novel phenomenon which developed itself upon the whole of the emerged portion of the surface of the earth, which was unoccupied by ice and snow, a portion too, by much the most extensive, a cause of a gradual absorption of the water which impregnated these strata, and thereby saturated the neighbouring strata of the superimposed atmosphere. This phenomenon is that of the vegetation, which, of necessity would by degrees manifest itself upon the new soil which would be exposed to the light, and which would develope itself with a rapidity which would increase to the epoch of man's appearance, who, in spreading over the surface of the earth, would again contend with this extension, which hitherto had been unchecked throughout the vegetable kingdom.

According to the experiments and the calculations of M. Chevandier, one hectare (about two acres) of forest annually absorbs of oxygen and hydrogen a quantity equivalent to 1800 kilogrammes of water, a result which has been obtained by the chemical analysis of wood which was perfectly dry; for there can be no question concerning the hygrometric water which plants absorb and emit, nor concerning that which the sap, the leaves, and generally the humid portions of trees absorb. On the other hand, a cubic metre (yard) of air at the temperature of 10 degrees, contains, when it is saturated with moisture, 10 grammes of water; consequently, one hectare of forest consumes during one year the quantity of water which would saturate, at the temperature of 10°, a stratum of atmospheric air of one hectare of surface, and of

18 metres of height. Hence, it is easy to perceive that this quantity of water is much larger than that which would be necessary to saturate the whole atmospheric column with a base of one hectare of surface; for if it be true that this column be somewhat higher than 1800 metres, on the other hand, its mean temperature is much below 10°. Thus, in supposing that a portion only of the continents had been covered with forests, it is not less true that the water absorbed by these forests has been more than sufficient to produce a notable diminution in the humidity of the surface of the earth and of the atmosphere, and consequently in the evaporation, as in the cold produced by this evaporation, and in the quantities of rain and snow; effects which, in their combination, must have produced a gradual retreat of the glaciers. This retreat has ceased when, at the termination of a certain time, an equilibrium has been established between the action of the causes which determined the absorption of the meteorological water and the action of those which produced its formation. At the same time, there is no doubt that if, from any cause, the vegetation were to disappear from the whole surface of the earth at the same time, the existing phenomena would assimilate themselves to those of the epoch which immediately preceded and accompanied the formation of glaciers, and would still reproduce themselves, although with less intensity, the soil being devoid of that humidity which resulted from its recent emergence.

It is almost unnecessary to observe that this general influence which the presence of great forests must exert upon the meteorological state of the atmosphere, after the appearance of the most recent formations, is not to be confounded with the local influence which the actual clearance and establishment of forests produces, and which is of an opposite nature with the foregoing; they are, in fact, contrary phenomena, whose discrepancy it is easy to account for. Finally, whilst assigning to the cause which I have pointed out the principal agency in the retirement of glaciers, and in the determination of the existing meteorological condition of the atmosphere, I am far from pretending that it is the only one; and I am far from denying the influence of those causes which M. Constant Prevost has pointed out. I only conclude as I began, by maintaining, that the existing causes amply suffice, without its being necessary to have recourse to a glacial era or period, to explain the fact generally admitted by geologists, namely, the successive appearance and disappearance of the ancient glaciers.

Meteorological and Astronomical Notices for December 1851. By Professor C. Piazzi Smyth, *Astronomer-Royal for Scotland.*

The Appendix to the second volume of the Observations of the National Observatory at Washington has recently been received here, and contains further interesting and important particulars with reference to Lieutenant Maury's important generalization on the motions of the atmosphere.

The most crucial and convincing proof of the truth of the Lieutenant's idea, that the trade-winds cross over into opposite hemispheres at the pole, instead of returning to their own poles, was mentioned in our last Notices, as being the fact of Ehrenberg having ascertained that in rain falling on the west coast of North Africa, and in Spain, certain dust had been dropped, which consisted mainly of infusorial animalcules of South American origin; this being precisely the direction which the trade-winds of the southern hemisphere, after getting up exhalations of all kinds in their passage over South America, should take on passing to the north of the equator.

It now appears that Ehrenberg had had sent to him specimens of this dust which had fallen at various periods between 1803 and 1849, and over various parts of NW. Africa, Spain, Portugal, France, and Italy, with the adjacent seas. The dust was almost always sent with the statement, that it *was* volcanic dust, or that it was the fine sand of the African deserts; while mere chemical analysis gave the following comparatively uninteresting and uninstructive table of contents:—

Water and organic matter, . .	=18·53	
Flinty earths, ...	=37·13	
Clayey, ...	=16·74	
Carbonic and chalk earths, . .	= 9·59	
Iron oxide, ...	= 7·65	
Manganese oxide, ...	= 3·44	
Alkali, ...	= 2·97	
Natron, ...	= 1·90	
Talc earth, ...	= 1·80	
Copper oxide, ...	= 0·25	
	———	100·00

To microscopic analysis, however, the contents were invariably found to be mainly organic, partly flint-shelled polygastric infusoria, partly fragments of flint earth plants (*Phytolitharia*), partly carbonaceous but uncarbonised fragments of other plants, and partly chalk-shelled Polythalamia; the Polygastrica and Phytolitharia evidently giving the flint earth, the Gallionella the iron and probably the manganese, and the Polythalamia the carbonic acid chalk earth.

In nine specimens of dust gathered at very different places and times, but of very similar constituents, there were found the following number of species:—

Polygastrica,	57
Phytolitharia,	46
Polythalamia,	8
Particulæ plantarum molles,	7
Insectorum fragmenta,	1
	119

Evidently, then, this was not volcanic dust, and it had moreover no symptoms of having been exposed to volcanic action.

And again, it could not be fine sand from African deserts, for there was so great a preponderance of fresh-water forms; and while there were many of them which were common to many parts of the world, there were none which were peculiar to Africa, but there was a large proportion which were peculiar to South America.

Of the above-mentioned 119 forms, 8 Polythalamia, 7 Polygastrica, and 2 Phytolitharia, only, belong to sea-water, the rest appertaining to fresh-water; among which the following are forms indigenous and peculiar to South America:—

Arcella constricta.
Desmogonium Guayanense.
Eunotia Camelus.
——— depressa.
——— pileus.
——— quaternaria.
——— quinaria.
Gomphonema Vibrio.
Himantidium papilio.
——— Zygodon.
Navicula undosa.
Stauroneis dilatata.
Suririella Peruana.
Synedra Entomon.

From all these circumstances, Ehrenberg had been led to conclude, altogether independently of Lieut. Maury, that there is some current in the atmosphere, tending from tropical South America to South-Western Europe, gathering dust and moisture in the above-mentioned regions, bringing them into the northern hemisphere, over the NE. trades, and dropping them on reaching the surface of the earth in its course to the NE. Further, the sources of the Orinoco, the "*dried upland swamp regions*," to which Ehrenberg was led for the habitat of some of his infusoria, have been separately described by Humboldt as precisely such localities, and vexed in the dry season with constant whirlwinds which fill all the air with fine dust.

The proof, therefore, that Lieut. Maury's theory of the trade-winds, and with them the motions of the whole atmosphere, is as complete as can be expected at so early a stage of the discovery.

His "wind and current charts," by which he appears to have been led to an enlarged mode of treating the subject, seem to be producing practical fruits also amongst navigators. On these charts he has inserted by symbols, from all available American log-books, the strength and direction of both wind and current each day. Thence a glance will shew, by the accumulated experience of hundreds of preceding voyages, what winds are likely to blow again on any succeeding occasion.

The individual symbols excessively multiplied in frequented parts of the ocean, being found somewhat puzzling, they are now being condensed, and the combined results will be given for each four square degrees of ocean in a wind-rose, or diagram of the points of the compass, which will shew the whole number of observations discussed, and the per centage proportion of each wind that blew.

In their present form, however, they have produced sufficiently marked results.

Of the arrivals at San Francisco, the quickest passages have been made by American vessels, and of these the six shortest have had the wind and current charts on board.

The average length of passage of all the American vessels through the year is 188 days, while the average of the six shortest, who had the assistance of the truly scientific principle of profiting by the experience of all their predecessors, was only 114 days!

Again, these charts have indicated a much shorter passage to the Line from the United States than vessels had been accustomed to follow from time immemorial; and logs had just been received of two vessels which had sailed at the same time, one a merchant vessel, and the other a man-of-war, and possessing therefore, it is by courtesy to be supposed, superior sailing qualities; yet by taking the old route, it had not reached the Line, when the other had not only passed it, but was even 1500 miles beyond!

The currents of the sea are receiving at the same time much elucidation, and an interesting system of cold currents from the polar regions alternating with warm ones from the equator; and again, under currents, always existing, and generally flowing against the upper one, and often with greater velocity, shew us that every part of the navigable ocean is instinct with this sort of life; and there is no more possibility of finding a still and currentless part of the ocean, than of discovering any part of a living human body where the blood does not flow.

When it is considered what a prolific source of shipwreck the currents of the ocean are, the importance of this elucidation of them will be fully understood; and though they may vary somewhat in strength and place, yet to be forewarned of their locality is something, and when astronomical observations cannot be procured to eliminate their effects, the thermometer seems to promise to indicate at least the direction of them.

Thus, entrance into the Gulf Stream, or a current carrying the ship from south to north, can be detected in the cloudiest weather, when there is so large a change in the temperature of the sea, as shewn in the following observations on board the Fairy:—

8 A.M.,	water 66°,	air 54°
9 ...	... 73	... 53
10 ...	... 76	... 55
11 ...	... 77	... 56

And again the cold current pouring down from Baffin's Bay, and penetrating with its vehement force far into the proper limits of the Gulf Stream, is shewn thus clearly by the log of the Argo:—

1850,	Dec. 17,	temperature of	water	68°
...	... 18,	...	...	47
...	... 19,	...	...	38
...	... 20,	...	...	37
...	... 21,	...	...	61

Further, a set of "*whale*" charts are being formed, or charts whereon the places and seasons wherever whales have been seen, are noted down; and while they promise to be of great service to that important branch of the American fisheries, seem to shew that the whales have a great deal more knowledge than we have usually given them credit for, and know a great deal more about the warm and cold currents of the ocean waters than we do, or have done.

It is not to be wondered that Lieut. Maury says that all these charts are eagerly sought and highly prized by practical American navigators, and it is hoped that British seamen will likewise both avail themselves of them, and contribute materials for perfecting them.

The task undertaken, while confessedly so useful, is a great and an endless one, for year by year as observations are multiplied, and it is hoped improved in accuracy (for instance, anemometrical determinations given in place of the mere testimony of the feelings, correction made for the motion of the vessel, and all directions corrected for the variation of the compass),—they must be continually added to the charts, and perhaps new ones will have to be made to suit the secular alterations of climate.

We can but fancy what an accession to knowledge would accrue, if the myriad log-books of all British vessels were to be searched, as the American ones now are, and made to disgorge the mass of facts which they retained so long and so secretly. But we should have a deal of leeway to make up before overtaking the Americans in this subject, which they have chosen for themselves. Perhaps it would be as well not to compete against them in exactly the same course. But there is another more limited subject which does not appear to have attracted their attention yet, viz., "*hurricane*" charts, where the track of every great whirlwind storm should be inserted with particulars. Had such existed, one can hardly think that such a disastrous encounter as that of the Pekin steamer with a Chinese typhoon, described in the *Illustrated London News*, for December 7, could well have occurred.

The account there printed, was sent to the paper by the Secretary of the steam company, as a most admirable instance of a typhoon being withstood, and as a glorification of the vessel and its owners. The captain, too, takes no small credit to himself, and imparts his praise extensively to the engineer, and all the officers concerned.

The vessel was on its voyage from Canton to the Straits, and was in lat. N. 16° 45′, long. E. 110° 45′; the log-book describes the falling of the barometer, and the rising of the wind and sea; and their portentous increase; then there follow successive entries as the night comes on, of the various sails which are blown away one after the other, of the boats washed off, and of masts and ropes broken, and of the utter consternation of the crew, who hide themselves in their despair. At length the vessel is no longer able to make any progress against the mighty odds, and all the *quasi* vital force of her large steam-engines, is employed merely to keep body and soul together; in keeping the vessel's head to the waves, and preventing her getting into the trough of the sea. It is confessed, that had not the vessel been a steamer; or being a steamer, had it not been so admirably strong and taught in every way, it must have foundered with all on board; at length the direction of the wind changes, the barometer begins to rise, and by the morning the storm has passed.

Now, it is doubtless extremely gratifying to hear, that British oak can withstand great roughness of weather, but was there any necessity of exposing it to such a death struggle as this? Not the slightest. The barometer falling shewed the approach of the hurricane, the direction of the wind shewed that the vessel was on the NW. edge of the circle, and there was abundance of sea-room to sail away northwards, where but a small space would have carried the ship out of the storm's reach, and have allowed it to pass by. But instead of that, it sailed away southwards 58 miles, that is towards the centre and most dangerous part of the storm, until compelled, in spite of itself, to desist from so mad and headlong a career. Fortunately, the centre was not reached, or probably the account had never figured in the *Illustrated London News:* but the greatest danger was incurred, and actual losses experienced, to an extent that would have furnished all the British navy with wind charts. The change of the direction of the wind towards morning, its abatement in strength, and the rise of the barometer, shewed that the storm then had passed away, and in the same path, and with the same characteristics, that all other Chinese typhoons have done before. This one was therefore nothing new, that a captain of so large a vessel should have been taken unawares by it. Moreover, those typhoons or hurricanes have been proved, by such a legion of melancholy catastrophes, to be far more than ships built by mortal hands can stand, when they get into the vortex (in one towards the end of the last century, in those same seas, 100,000 men are said to have perished); that no passenger merchantman, steamer, or sailing vessel, is justified in not getting out of its way, when there is plenty of sea-room. And if the steam company do not mulct their captain in the cost of all the sails, ropes, masts, and boats carried away, it is to be hoped that the underwriters will take up the case. At any rate, if so prominent an instance should induce some official recognition of the importance of making and enforcing the use of a series of hurricane charts, science will be the better for it, and the lives of those of our countrymen who have to voyage in tropical seas, will be so much the safer.

Saturn's Rings.—According to a lithographed drawing prepared by Mr Lassel, as the result of his observations with his reflecting telescope, the new dark ring, discovered by Prof. Bond, is now broader, that is, extends more nearly to the ball, than when first seen. Mr Hartnup's observations with the Liverpool equatorial also give the same result.

To account for the alteration in the appearance of the rings, the separations sometimes visible and sometimes not, Mr Bond not finding that such effects could well result from any difference in form of surface, as by mountains on the rings, has supposed that they may be fluid. The discrepancies of observations might then be more easily explained by a variable constitution of the ring, consisting in the frequent formation of divisions and their subsequent annihilation. Prof. Benjamin Pierce, of Harvard University, U.S., has followed in the same line, and has shewed that a more recondite application of the principles of fluid action lead to more definite views.

He has demonstrated, indeed, from purely mechanical considerations, that the ring cannot be solid, and he maintains, unconditionally, that there is no conceivable form of irregularity, and no combination of irregularities, consistent with an actual ring, which would serve to retain it permanently about the primary, if it were solid; and he considers that La Place's statement of the sustaining power of an irregularity, in which he has been blindly followed by his successors, was but a careless suggestion dropped at random, and never subjected to the scrutiny of a rigid analysis. But Prof. Pierce shews that in the case either of one irregularity, or of many, that they will not permanently support the ring if solid, but that they will rather tend to accelerate its fall and destruction.

He then considers the possibility of their being streams of fluid somewhat denser than water, and flowing around the planet. The extraordinary thinness of the ring allowing the fluid to be supposed to be of uniform density; then with the mass, width, diameter, and velocity of rotation as observed, a proportion for the thickness and width of each ring, may be computed by the respective lengths in each direction, which will give equality of fluid pressure in the centre. Hence the whole number of component rings to make up the grand ring as observed, may be computed, and the first approximation has given 20, which Prof. Pierce considers the maximum limit. The definite width of the elementary rings, is, he says, to a certain extent, analogous to the definite size of the drops of water from a vial; and as those drops may be observed to break off from the fluid above with quite an abrupt line of separation, so will the dividing of the rings of Saturn, as the fluid approaches that state of rest which is necessary for the phenomenon, occur with a swift and abrupt sinking in at the proper distances.

Investigating then into the stability of such a fluid ring or rings, Prof. Pierce was surprised to find that after all, the motion of the centre of gravity was *not* controlled by the primary; that it retains the individual particles from flying apart, and keeps them in the form of a ring, but it has no influence on their motion as one body. The ring might therefore, so far, move to such an extent in its plane as to be brought into contact with the ball of the planet and destroyed. He found, however, that the sustaining power exists in the satellites *exterior* to the ring, as was indeed supposed by Sir John Herschel, in his Outlines of Astronomy.

Thence Prof. Pierce concludes, that no planet can have a ring, unless it is surrounded with a sufficient number of satellites properly arranged; and that Saturn is the only one so furnished. He shews moreover, that the Sun has not its satellites, *i.e.* the planets, properly arranged for supporting a ring, or that the only possible part of the system for such a phenomenon would be just within the powerful masses of Jupiter and Saturn, and that supposing the Sun ever had been surrounded by some ring of matter comparable to the zodiacal light, then defects in the maintaining power of the planets outside might cause the centre of gravity of the ring to begin to move until is was broken by being brought into contact with the Sun or some of the interior planets, when either asteroidal planets or comets might result under different circumstances.

Pressure of business has prevented Prof. Pierce at present from giving the whole of his mathematical investigations, but meanwhile his results will be received with great faith, after the unusual ability and the scrupulous regard to absolute truth of hypotheses which he shewed in his difficult researches into the mutual perturbations of Uranus and Neptune.

New Planet Eunomia.—As Messier complained that when grieving for his lost wife, some other astronomer had succeeded in finding a comet, which would otherwise assuredly have fallen an earlier prize to his superior skill in searching the heavens; or as Bonaparte exclaimed on hearing of the battle of Trafalgar when he was on the victorious field of Austerlitz, that "he could not be everywhere at once;" so the great English planet discoverer, Mr Hind, may complain that he cannot be attending to everything; that when he goes with a portable instrument to observe a total solar eclipse in a foreign country, he cannot be searching for new planets in Mr Bishop's Observatory. And at least it is an additional proof of the richness of the field of discovery, that when almost all the astronomers of note had gone to the Continent to observe the eclipse of July 28, another, M. Gasparis, of Naples, who could not stir from home, succeeded in finding, only the next day, another of the asteroidal planets. It appeared as a star of the 9th magnitude, and has been named Eunomia. Its place amongst the other members of that celestial family, will be found by the following determinations, viz., mean distance = 2·46, periodic time 1406 days. Its position in the sky, when found, was $18^h\ 16^m$, R. A., and 26° 4′ south declination.

New Satellites of Uranus.—On November 3d, Mr Lassel of Liverpool, as active and successful a discoverer of satellites as Mr Hind or M. Gasparis of planets, wrote to announce of his suspected discovery in October 24th having been confirmed; and that he can now state confidently, that Uranus has two satellites interior to the closest, suspected by Sir W. Herschel. This had a period of five days, but the two new ones have for their time of revolution four days, and 2·5 days respectively.

"These new satellites," he says, "are very faint objects, probably much less than half the brightness of the conspicuous ones, and generally the nearest has appeared the brightest. All four were steadily seen at one view in the 20-feet equatorial, with a magnifying power of 778 in the more tranquil movements of the atmosphere. The finest definition of the planet and freedom from all loose light in the field of view is necessary for the scrutiny of these most minute and delicate objects."

Standard Thermometers.—Mr Sheepshanks, who has been engaged for some time past in the construction of a standard scale of length, has at last got over one of the principal difficulties, viz., procuring sufficiently accurate thermometers to ascertain the temperature, and the consequent expansion of the scale. His success here will doubtless be of service to others elsewhere, as a thermometer is so essential an instrument of all scientific research, and though so apparently simple, is one of the most difficult problems in practical science. The stage of accuracy to which Mr Sheepshanks has arrived, is to be able to *depend* on a thirtieth, or even a fiftieth, of a degree of Fahrenheit; the height of the mercurial column being read off by a small telescope and micrometer. The bulbs are generally about ½ to ¾ inch in diameter, and the tubes, which have the divisions etched on the glass, are in the longest cases 18 inches in length. These he calls generating thermometers; and as no thermometer is constant in *wide* ranges, and at *different* times, he has other thermometers, smaller, and with only a portion of the scale from freezing to boiling; and prefers to use a special instrument for a special temperature.

The first practical difficulty is the equality of the bore of the tube: round bores are most even, but flat ones are easy to read off. In either case, care should be taken to pick out one with no *sudden* irregularities. To examine into the quantity of these, portions of the columns must be broken, and passed along the tube, first with one length of column, bisecting the extent of the scale, then trisecting, and so on, until every tenth or every fifth division has been tested. A little skill is required to continue to break off portions of the column without the application of a lamp to the bulb, as has previously been practised; and consists in dexterously reinverting the thermometer, which has just been turned downwards, and so bring the vacuum bubble, which will thereby have been formed in the bulb, to the neck of the tube.

Exceeding pains are then taken, in determining the freezing and boiling points, that the pounded ice in the one case, and the boiling water in the other, are neither above nor below their natural temperatures; but even when this is accomplished there arises the greater difficulty still, that heat seems to produce two sorts of expansions on bodies, viz., the ordinary, or that which ceases with the increase of temperature, and may be called the periodical expansion; and another, which may be called a secular expansion, much smaller in amount than the other, but continuing to exist days, or weeks, or months, according to the bulk of the article acted on.

For strict purposes, therefore, to determine correctly temperatures below boiling, the thermometer should be boiled just previous to being used. But to avoid this trouble, Mr Sheepshanks prefers, for noting ordinary climate temperatures, to have a thermometer marking only to about 70° to 80° Fahr., compared from time to time with one of the generating thermometers, and having its freezing point occasionally tested. Thus avoiding in any one instrument the application of any exceeding variations of temperature.

This secular change probably affects the glass of the bulb more than the mercury contained therein, and is equally present in every metal, and indeed all substances, greatly to the confusion of our attempts to construct standard scales for exact scientific purposes. The *age* of the bar, and its former experiences, now seem to be elements in determining its length, in addition to the temperature at the moment.

The old custom of making measuring-rods of wood was necessarily exploded before the advancing requirements for accuracy, when it was found that, in addition to expansion from heat, which could be measured, there was other expansion from moisture, which could not be measured accurately, and other alteration still from some sort of working or reaction of the late organic forces, which had vivified the wood, and made the tree, and are more difficult than ever to examine into, and seem to defy all our means of measuring their quantity and computing their effects. While bone or ivory, anything in fact which has had life in it, is as little to be trusted as wood.

Recourse was then had to metals, and men revelled in the fancied simplicity and certainty of the corrections to be applied to deduce the true length of a bar at any temperature. Bars of all metals, and in the state of metal, cast or wrought, hammered or rolled, round, flat, thick, thin, hollow, and solid, were all indifferently used: the thermotic expansion being ascertained in each case, by trying the length first in a freezing mixture, then in boiling water, and taking $\frac{1}{180}$ of the difference so found, as the correction due to 1° Fahr.

But now it is found by close microscopic measurements, that according to the degree to which the particles of the bar were distressed in the metallurgic operations of rolling, hammering, &c., so will it have a greater tendency to return, though slowly and through long intervals, to some former shape. And as we cannot ascertain all the blows and severe trials which the bar may have undergone in its process of formation, or probably correct for them, if we did, for the effects will vary with every different metal and every variety of each metal, we can only eschew all recently manufactured bars, and prefer cast to wrought metal.

Next it has been ascertained that no metal expands uniformly with the mercurial thermometer, and therefore the making the correction equal to so many $\frac{1}{180}$ parts of the whole expansion, as the thermometer should be above 32° F., is by no means true for points between 32° and 212°.

And lastly if the bar be heated up to 212°, it will be found not to come down again at once on cooling to its former length at 32°. As therefore so high a temperature is unnecessary, because we never have to use the rods, or to make measurements with them in an atmosphere of that temperature, the once favourite plan of boiling or roasting bars, so as to get their expansion indicated to a great extent, is now given up; and the better method is adopted of leaving the bars altogether to themselves and to nature. They are allowed to take any temperature that they please under the usual changes of climate; their lengths are carefully watched under all those slightly varying alterations of natural heat; observations are greatly multiplied; and equations of condition at last bring out the true law of expansion.

SCIENTIFIC INTELLIGENCE.

METEOROLOGY.

1. *The Climatology of Arctic America in reference to the fate of Sir John Franklin.*—" The idea of a cycle of good and bad seasons has often been mooted by meteorologists, and has frequently recurred to my thoughts when endeavouring to find a reason for the ease with which at some periods of Arctic discovery navigators were able to penetrate early in the summer into sounds which subsequent adventurers could not approach, and to connect such facts with the fate of the discovery ships. But neither the periods assigned, nor the facts adduced to prove them by different writers, have been presented in such a shape as to carry conviction with them, until very recently. Mr Glaisher, in a paper published in the Philosophical Transactions for 1850, has shewn, from eighty years' observations in London and at Greenwich, that groups of warm years alternate with groups of cold ones, in such a way as to render it most probable that the mean annual temperatures rise and fall in a series of elliptical curves, which correspond to periods of about fourteen years, though local or casual disturbing forces cause the means of particular years to rise above the curve or fall below it. The same laws doubtless operate in North America, producing a similar gradual increase, and subsequent decrease of mean heat, in a series of years, though the summits of the curve are not likely to be coincident with, and are very probably opposed to those of Europe, since the atmospherical currents from the south, which in a period raise the annual temperature of England, must be counterbalanced by currents from the north or other meridians. The annual heat has been diminishing in London ever since 1844, according to Mr Glaisher's diagram, and will reach its minimum in 1851. It can be stated only as a conjecture, though by no means an improbable one, that Sir John Franklin entered Lancaster Sound at the close of a group of warm years, when the ice was in the most favourable condition of diminution, and that since then the annual heat has attained its minimum, probably in 1847 or 1848, and may now be increasing again. At all events, it is conceivable that, having pushed on boldly in one of the last of the favourable years of the cycle, the ice, produced in the unfavourable ones which followed, has shut him in, and been found insurmountable; but there remains the hope that if this be the period of the rise of the mean heat in that quarter, the zealous and enterprising officers now on his track will not encounter obstructions equal to those which prevented their skilful and no less enterprising and zealous predecessor in the search from carrying his ships beyond Cape Leopold."—*Sir John Richardson.*

2. *Atmospheric distribution of Iodine.*—M. Chatin, the disco-

verer of iodine in the atmosphere, is continuing his researches on this subject. The general result of his latest observations leads him to conclude, that the nearer he approached the Alps the smaller was the quantity of iodine, and that in some districts, as Maurienne, this atmosphere contained no iodine.

GEOLOGY.

3. *On the Internal Structure of Mountains. By B. Cotta.* (*Leonhard u. Bronn's Jahrb. f. Min. u.s.w.* 1851, p. 181-2.) —In a letter to Dr K. C. v. Leonhard, the author states that in a short memoir on the Internal Structure of Mountains, lately published at Freiberg, he has attempted the physiology, as it were, of mountains, in shewing the different phases of their formation and destruction. The chief results arrived at are—

1. The mountains did not suddenly arise, but were formed by degrees, sometimes during very long periods of time.

2. For their position and direction there are as yet no general laws positively known.

3. All true mountains are results of elevatory volcanic (plutonic) action.

4. The majority, however, in their present form, are at the same time the result of a later destructive process (the action of water), in very unequal degrees.

5. The mountain-elevations are to be distinguished as local, from the continental elevations of great tracts of land, which latter may be bare swellings, unless eruptive rocks find a local vent.

6. Horizontal forms of the mountains correspond in some degree to the grouping of the volcanoes,—the single mountain masses (*Massen-Gebirge*) to the central volcanoes (*Vulkan-Gruppen*), the mountain chains to the lines of volcanoes (*Vulkan-Reihen*).

7. Of the origin of mountains the author distinguishes three principal kinds, and very many forms of combination, and stages of development and destruction. The three kinds of origin are—

a. By the efflux and superficial accumulation of eruptive rocks;—volcanic mountains.

b. By the elevation of existing hard portions of the earth's crust, caused by eruptive rocks penetrating upwards;—plutonic mountains.

c. By lateral pressure, and, in consequence thereof, the folding of existing hard portions of the earth's crust.

8. Several of these kinds of development, however, sometimes occur in combination with one another.

9. The mountains originating in the elevation of the existing hard portions of the earth's crust, owing to the upward pressure and penetration of eruptive masses, exhibit the most manifold diversity of stages of destruction, whereby they fall into mountains with folded

strata (*Falten-Gebirge*), crystalline slate mountains, and central mass mountains of upper, middle, and lower section.

10. The mountains with folded strata of this sort, however, are not always distinguishable from those originating in lateral pressure.

11. Of especial importance in judging of the relative age of the mountains—besides the distinction of elevated and non-elevated beds brought forward by E. de Beaumont—is the fixing of the mountain chains as lines of separation between deposits during determined periods; recognizable by dissimilar characters in the series of sedimentary formations on two or more sides.

12. The volcanic mountains are distinguished from the plutonic, consolidated within the earth, both by their external form and by their mineralogical conditions. The first form superficial, the second form subterranean, cones of eruption. The section of these last exhibits (for example) the so-frequently referred to granite-ellipsoids. Both, however, fill up also narrower fissures, in which they are then mostly crystallized somewhat otherwise than in the great principal masses.

4. *On German Tertiary Formations. By F. Sandberger.* (*Leonhard u. Bronn's Jahrbuch f. Min. u.s.w.* 1851, p. 177.) —Tertiary formations of the age of the Mayence Basin are widely distributed in Germany. That the Brown-coal formations of Westerwald and the Lower Rhine, as also that of the Vogelsberg, belong to this period, is easily proved by their fossil shells and plants. With regard to their Vertebrata, Von Meyer long since supplied the necessary proof. Moreover, the Brown-coal formations of Miesbach, in Upper Bavaria, contain *Cyrena subarata*, Bronn, *Cerithium margaritaceum*, and other characteristic forms of the Mayence Basin. The Vertebrata of the Molasse of Switzerland agree also with those of the last deposit; and in respect to North Bohemia, the elaborate work of Von Meyer and Reuss* affords also a similar result. The Mayence Basin is, moreover, the type of a whole series of such deposits, as is the London Basin with respect to the old tertiary clays of the Baltic plain.—*Quarterly Journal of the Geological Society*, vol. vii., No. 28, p. 118.

5. *On an extensive Rock-Formation of Siliceous Polycystina from the Nicobar Islands. By Prof. Ehrenberg.* (*Berlin Monatsbericht*, 1850, p. 476–478. *Leonhard u. Bronn's Jahrbuch f. Min., u.s.w.* 1850, p. 237.)—Hitherto, Barbadoes only has afforded rocks with Polycystina. The Nicobar Islands lie in nearly an equal latitude with it, but in the East, instead of the West Indies. They consist of syenitic and serpentinous porphyry or gabbro-rock with pyrites, but without any recent volcanic ejectments, on which, to the height of 2000′, lie clays, marls, and calcareous sandstones, rich in *Polycystina*. The author has already obtained

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* Palæontographica, II. 2.

from hence 100 species, which are partly identical with the 300 species from Barbadoes. The islands Car Nicobar and Comarta are especially remarkable in this respect, and on the latter exists a hill 300′ high, throughout which the Polycystina-clay occurs. A light meerschaum-like clay and shale (tripoli, polishing shale) found there and at other places is composed nearly altogether of these bodies, mixed with many Spongolithes. These clays are generally traversed by lignitiferous deposits, and by syenitic gravels.—*Quarterly Journal of the Geological Society*, vol. vii., No. 28, p. 118.

6. *Mr J. B. Guimet's Process for the Manufacture of Artificial Ultramarine.*—Previous to the year 1828, all the ultramarine in use was obtained from the *Lapis Lazuli*, a rare mineral procured from Siberia. A common ultramarine thus obtained, is, at the present time, sold at seven guineas per ounce, and the price of a genuine and very choice article, is upwards of twenty guineas per ounce. From its great costliness, the use of this pigment is confined entirely to the artist. Several analyses of ultramarine were undertaken with the view of finding out a method of making it artificially. These analyses shewed it to be a compound of silica, alumina, sulphur, soda; but the supposed colouring principle for some time evaded all attempts at its detection. At last, M. Guimet of Lyons, in the year 1828, aided by these analyses, and encouraged by the offer of a prize of 6000 francs from the *Société d'Encouragement* of Paris to the person who should succeed in the manufacture of artificial ultramarine, hit on the happy idea of giving up further search for the hidden colouring principle, and confined his attention to the combination of the several colourless ingredients which chemical analysis pointed out as the constituents of natural ultramarine. The result was the discovery of artificial ultramarine. M. Guimet kept his process a secret, selling his ultramarine at 42s. per pound. Gmelin, Persoz, and Robiquet afterwards discovered the process, and published the mode of preparing this pigment, since which time its manufacture has extended in Germany and in France, and has latterly been introduced into this country.

Ultramarine appears to be a compound of silicate of alumina and silicate of soda, with sulphuret of sodium, and the colour is supposed to be due to the reaction of the last constituent upon the former two. It may be prepared, according to Gmelin, by rapidly igniting a mixture of equal parts of silica, carbonate of soda, and sulphur, first adding a sufficient quantity of a solution of soda to dissolve the silica. The result is a bluish-green mass, which, by ignition in contact with air, becomes blue. Ultramarine is now sold as low as fifteenpence per pound. It is applied to various purposes in the arts, such as paper-staining, the *azurage*, or blue tinting of writing papers, starch, ground white lead, &c., and has recently been applied to the printing of cotton goods. It has superseded smalts in many industrial purposes; but as it is not an enamel colour, its employment is not applicable in the colouring of china and earthenware.—*Pharmaceutical Journal and Transactions*, vol. xi., No. v., p. 230.

MINERALOGY.

7. *Exhibition of Statues and Gems in the Crystal Palace.*—The nature of the articles exhibited depends as much upon the character of the building which is to receive them as it does upon their own individual character. In a building which admits the whole light of the sky, except where it is eclipsed by the beams of its carpentry, it would be impossible to make a favourable exhibition of pictures, while statues could be advantageously displayed. When an oil painting is illuminated from numerous points, or by broad beams of light, the varnished surface, thus rendered visible, destroys the finest touches of the artist, and removes the illusion which he had produced. In like manner, gems, such as the diamond, which derive their principal beauty from the prismatic spectra which they produce, lose all their charm when exhibited in a palace of crystal, while gems and precious stones, which derive all their beauty from their colour, are displayed to great advantage. The great *Koh-i-noor*, or Mountain of Light, the *Durra-i-noor, or the Sea of Light*, and the fine *blue diamond of Mr Hope*, have less effect, as now exhibited by daylight, than a piece of glass of the same size and tint would have, if exhibited in a private room with two or three windows. In the spectra produced by broad luminous spaces, all the colours are recombined into white light, and hence the disappointment which every person has experienced at the first sight of these singular gems. Were the same gems to be worn by a lady in a drawing-room, with numerous bright lights, their effect would astonish the company.* The fine coloured refractions of the diamond disappear also under other circumstances. When the diamonds are very small, and set closely together, the numerous prismatic spectra which they produce are mingled, and produce white light on the retina of the eye, and this diminution of colour increases with the number of lights. When small diamonds, however, are at a sufficient distance from each other, they are seen to the greatest advantage when the lights are sharp and numerous.

As the sight of rare precious stones must always be exceedingly interesting, because they are never seen in collections of minerals, and when in the possession of individuals can only be seen by their private friends, it would have been desirable to place all the diamonds (as the Koh-i-noor is, on Fridays and Saturdays), in a dark apartment, illuminated by numerous small and brilliant lights. Till this was done with the Koh-i-noor, nobody had any idea of its purity and beauty, and, indeed, nobody till then could say that it was not a piece of glass.*—*North British Review*, No. xxx., p. 542.

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* Many intelligent persons mistook the hollow foil for the great diamond itself.

ZOOLOGY.

8. *Flying-Fish.*—The common opinion that the motion of the Flying-fish through the air is nothing more than a vigorous *leap*, sanctioned as it is by many honoured names in science, I have long believed to be incorrect, having on several former occasions seen what appeared to me a distinct motion of the fins. To settle this point was one of the desiderata which I had particularly noted down on commencing this voyage; and the result has fully confirmed my belief. The observations as they occurred, I shall quote in the form in which they were recorded.

Nov. 20*th.*—Lat. 19° 24′ N., long. 41° 5′ W.—Many Flying-fishes appeared in the course of the day: the first we had observed. They were the silvery species commonly seen in the Atlantic, of middling size, with clear wings; probably *Exocœtus volitans.* I now feel certain that these fishes have power to change their direction when in the air; more than one, which I saw to-day, *turned aside at nearly a right angle.*

Nov. 22*d.*—Flying-fishes leap from the sea every few minutes; several made courses distinctly angular, and some, I am quite sure, *rose and sunk in undulations.* To confirm my own observations, I requested a gentleman on board to notice this point; and he was quite certain of both of these facts.

Nov. 24*th.*—I observed to-day a Flying-fish, after flying a short distance, suddenly turn downward, abruptly and perpendicularly, as if alarmed, and enter the water. The action exactly resembled that of a bird.

Nov. 25*th.*—Several times I have observed in the flight of the *Exocœtus*, when near, an occasional fluttering of the pectorals. In general, these wing-fins appear motionless; but at the moment of rising to avoid the crest of a wave, there is a slight but rapid vibration of these organs, distinctly perceptible, if the fish be pretty close to the ship. I saw an *Exocœtus* to-day which was much larger than the species hitherto observed, with the pectorals wholly of a sooty black colour. Probably it is the *Exocœtus Noveboracensis* of Dekay. The others are still rather numerous, but do not rise in flocks.

Nov. 27*th.*—This morning multitudes of Flying-fishes rose, disturbed by the ship; a distinct species, differing from both the former in many points. This species is much smaller; the pectorals are so delicately transparent as to be almost invisible; the upper parts are of a fine deep blue; their flight is swifter, more hurried, and continued for a shorter distance; they often merely shoot along at the surface, just cutting the water, and sometimes emerge for five or six feet only. The former appears more tapered at the extremities than that of the species hitherto common.

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* The introduction of ground glass globes into our apartments, however beautiful they may be as objects seen by the eye, destroy the beauty of all other objects. Silver and gold plate, and all other objects that derive their beauty from the reflected light, lose their polish, and have actually the same appearance as if their surface was *ground.* The coloured spectra, too, produced by the diamond and other precious stones, are all *dimmed* as if they were seen through ground glass.

Nov. 29th.—I noticed a Flying-fish curve its course so as to describe *more than half a circle.*

Nov. 30th.—Before breakfast the motion of the ship disturbed multitudes of Flying-fishes of the blue-backed species, which flew in shoals every moment from each side of the bows. Many Bonitos pursuing them were likewise leaping from the surface; at length a seaman from the martingale struck one of the latter with the grains and secured it. It was a beautiful fish, remarkably plump and hard; the rainbow hues of the skin were most rich and lustrous, the pink predominating. Several black stripes running along each side marked it as the *Thynnus pelanys* of Cuv. and Val. We ate it for dinner, and found the flesh pleasant, but rather dry. In its stomach were six of the Blue-backed Flying-fishes partly digested. Some large oceanic birds were likewise pursuing the little aëronauts, swooping down amidst the flitting shoals. As far as I remember, this is the only occasion in which the pursuit of the *Exocœtus*, by either winged or finned enemies, has ever occurred to my observation; I incline to think that it is much oftener described than seen.

Here end my notes of the Flying-fish; except that long afterwards I saw two or three of the blue-backed species skimming the surface of Bluefield's Bay. Besides the fact, which these notes appear to me to prove, that the *Exocœti* have the power of increasing, directing, and terminating their progress while in the air, by the action of their pectorals—a true flight, those connected with the geographical distribution of the species are worthy of notice. The common Atlantic species, which I take to be *volitans*, suddenly appeared in considerable numbers in long. 41°, or just midway between Africa and the West Indies. They continued to be abundant until within a day's sail of Antigua, where they were replaced by the little blue-backs, and were seen no more. This beautiful little species suddenly became quite as abundant as the former had been, and so continued until we neared Hayti. The great Black-winged kind appeared three days to windward of Antigua, and continued to appear conjunctly with the Blue-back, but rarely more than two or three in a day. The last was seen near the west end of Hayti.—*A Naturalist's Sojourn in Jamaica. By P. H. Gosse*, p. 9.

MISCELLANEOUS.

9. *Monticelli's Collection of Minerals at Naples for sale.*—This

collection, now in the hands of a nephew of the late Monticelli, the distinguished Italian mineralogist, is offered for sale. It contains 4000 specimens. There are over 400 Vesuvian specimens, containing the largest and finest suite of Vesuvian specimens and varieties extant, all thoroughly labelled. Besides these, it includes also a beautiful series of Elba and Sicilian minerals, and a general collection rich in the species of the most celebrated European localities.—*American Journal*, vol. xii., No. 35, p. 301.

10. *Science of Pisa.*—Pisa is a fine city, and its university contains the best general collection in zoology, geology, mineralogy, and botany, in all Italy. It is justly celebrated at home for the high character of its scientific men, and deserves to be generally applauded for their sakes,—Chas. Matteucci,—the two Savi, sons of the renowned G. Savi, professor of botany at Pisa until his death,—Joseph Meneghini, professor of mineralogy and geology,—Piria, the chemist, are all names of just celebrity, and we found them most agreeable and enthusiastic men. Professor Meneghini is a young man, and has held his office only two years, in place of his unfortunate predecessor Professor Pila, who was shot in one of the republican battles in 1848. He is also a zoologist and botanist, and has edited "Observazione Postume di Zoologia Adriatica del Prof. Stefano Andrea Renier, Venezia, 1847," containing 16 plates, in folio, principally occupied with figures of sponges.—*American Journal*, vol. xii., No. 35, 2d Series, p. 300.

11. *Nocturnal Forest Sounds.*—Various and strange are the sounds which strike the ear of one benighted in the forests of Jamaica. Some of these are the voices of night birds, the rapid articulations of the Piramidig, the monotonous call or startling scream of the White Owl, the shrill wail of the Dusky Owl, the hoot of the Potoo, or the loud and reiterated cries of the Clucking Hen; and some are insect sounds. But, besides these, there are some which are certainly produced by reptiles, though it is difficult to identify them. Nearly every night, at certain seasons, there ascends from the woods around Content a continual snoring of various tones, the voices of numberless Tree-frogs, or, as they are here called, Toads. They are said to reside in the large ventricose leaves of the greater Wild Pines, especially that fine one *Tillandsia lingulata*, which, about the end of July, sends up a magnificent flower, somewhat like a huge carnation, with broad outer petals of a rich crimson hue and polished surface, and a cluster of smaller interior ones of pale yellow. In the coolness and moisture of these natural reservoirs, always half full of water collected from rains and dews, the Tree-frogs delight to lie, finding in them circumstances eminently congenial for the maintenance of cutaneous humidity, so essential in these reptiles to respiration. They are very rarely seen, and, but for their vocal powers by night, we should scarcely be aware of their existence; the number and universality

of these sounds, however, in the mountain woods, during the hours of darkness, prove that they are very abundant. Even when seen by day, their agility in leaping renders it a difficult matter to lay hands on them. The sounds in question bear a strong resemblance to the objurgations of an inveterate snorer, but are much louder; or sometimes remind one of the groaning and working of a ship's timbers in a heavy gale at sea.

These are probably the voices of some of the greater Hyladæ. But there are other and different noises still. While I am writing this note at Content—it is a lovely night in June—all around I am saluted with strange sounds. Now and then comes the singularly harsh and cracked voice of the Gecko, like the notes of a child's penny trumpet, or like a stick drawn across the teeth of a comb:—this I am familiar with. But I hear another voice, far more abundant, but quite unknown to me. It is now (about midnight) coming up from every part of the moonlit forest below me, with incessant pertinacity. It is a clear shrill note, so like the voice of a bird, and in particular so like that of the Solitaire, that it might easily be taken for it, but for the inappropriate hour, and the locality. Like that, it is beautifully trilled or shaken, and, like it, the individual voices are not in the same key. As I now listen to the mingling sounds, I distinguish two particularly prominent, which seem to answer each other in quick but regular alternation; and between their notes there is the difference of exactly a musical tone. I have little doubt that this is the sexual call of some Tree-frog. The groanings and snorings, which are sometimes so incessant, I do not now hear, except one such sound now and then in the course of an evening.—*A Naturalist's Sojourn in Jamaica. By P. H. Gosse*, p. 358.

List of Patents granted for Scotland from 22*d September to* 22*d December* 1851.

1. To John Macdowall, of Walkingshaw Foundry, Johnston, in the county of Renfrew, North Britain, engineer, "improvements in cutting wood and other substances, and in the machinery or apparatus employed therein, and in the application of power to the same."—22d September 1851.

2. To Henrietta Brown, of Long Lane, Bermondsey, widow and executrix of the late Samuel Brown, "improvements in the manufacture of metallic casks and vessels."—24th September 1851.

3. To Robert Newell, of the city of New York, in the United States of America, lock manufacturer, and a citizen of the said United States, "certain new and useful improvements in the construction of locks."—24th September 1851.

4. To Laman Baker Pitcher, of Syracuse, in the State of New York, and United States of America, gentleman, "improvements in apparatus for regulating motive-power engines."—24th September 1851.

5. To John Wormald, of Manchester, in the county of Lancaster, maker-up and packer, "improvements in machinery or apparatus for spinning and doubling cotton, wool, silk, flax, or other fibrous substances."—29th September 1851.

6. To Charles Watt, of Kennington, in the county of Surrey, chemist, "improvements in the decomposing of saline and other substances, and separating their component parts, or some of them, from each other, also the forming of certain compounds or combinations of substances, and also in the separating of metals from each other, and in freeing them from impurities."—29th September 1851.

7. To Thomas Kennedy, of Kilmarnock, in the county of Ayr, North Britain, gun manufacturer, "improvements in measuring and registering the flow of water and other fluids."—29th September 1851.

8. To Elijah Galloway, of Southampton Buildings, in the county of Middlesex, civil engineer, "improvements in steam-engines."—30th September 1851.

9. To William Johnson, of Millbank, in the city of Westminster, gentleman, "improvements in ascertaining the weight of goods."—1st October 1851.

10. To William Barker, of Hulme, near Manchester, in the county of Lancaster, millwright, in the employ of Joshua Schofield and Sons, fustian dyers and finishers, of Cornbrook, near Manchester aforesaid, "improvements in machinery for chipping, rasping, and shaving dyewood and other materials, and in apparatus connected therewith."—6th October 1851.

11. To Henry Curzon, of Kidderminster, in the county of Worcester, civil engineer, "improvements in the manufacture of carpets and rugs."—10th October 1851.

12. To Thomas Lightfoot, of Jarrow Paper Mills, South Shields, in the county of Durham, paper manufacturer, "improvements in machinery applicable to the manufacture of paper."—10th October 1851.

13. To George Robins Booth, of Portland Place, Wandsworth Road, Surrey, "improvements in generating and applying heat."—15th October 1851.

14. To William Onions, of Southwark, in the county of Surrey, engineer, "improvements in the manufacture of steel."—15th October 1851.

15. To Daniel Dalton, of Spon Lane, in the parish of Westbroomwich, and county of Stafford, iron-founder, "improvements applicable to railways."—16th October 1851.

16. To Henry John Betjemann, of Upper Ashby Street, Northampton Square, in the county of Middlesex, "improvements in connecting parts of bedsteads and other frames, and in machinery employed therein."—16th October 1851.

17. To Thomas Sanders Bale, of Cauldon Place, in the county of Stafford, china manufacturer, "certain improvements in the method of treating, ornamenting, and preserving buildings and edifices, which said

improvements are also applicable to other similar purposes."—20th October 1851.

18. To William Onions, of Southwark, in the county of Surrey, engineer, "improvements in the manufacture of nuts and bolts; also of steps, bearings, axles, and bushes; also of mills and dies for engravers; also of bells, lathe, and other spindles; also of weft forks, shuttle tongues, and lips for looms; also parts of agricultural implements, chains, roller-guides, and throstle-bars, by the application of materials not hitherto used for these purposes."—20th October 1851.

19. To William Jean Jules Varillat, of Rouen, in the republic of France, manufacturer, "improvements in the extraction and preparation of colouring, tanning, and saccharine matters, from various vegetable substances, and the apparatus to be used therein."—20th October 1851.

20. To William Fawcett, of Kidderminster, in the county of Worcester, "certain improvements in the manufacture of carpets."—21st October 1851.

21. To Robert Griffiths, of Havre, engineer, "improvements in steam-engines and in propelling vessels."—21st October 1851.

22. To Frederick William Mowbray, of Leicester, gentleman, "improvements in machinery for weaving."—21st October 1851.

23. To George Fergusson Wilson, managing director of Price's Patent Candle Company, Vauxhall, David Wilson, of Wandsworth, Esq., James Childs, of Putney, Esq., and John Jackson, of Vauxhall, gentleman, all in the county of Surrey, "improvements in presses and matting, and in the process of, and apparatus for, treating fatty and oily matters, and in the manufacture of candles and night lights."—22d October 1851.

24. To Donald Henderson, of Glasgow, ironmonger, "an improved apparatus for generating gas, which apparatus may be used for heating and other similar useful purposes, and other apparatus for heating and ventilating."—22d October 1851.

25. To Edwin Deely, and Richard Mountford Deely, of Avdnam Bank, in the county of Stafford, flint and bottle-glass manufacturers, "improvements in the construction of furnaces for the manufacture of glass."—31st October 1851.

26. To Alfred Vincent Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, mechanical draughtsman, "certain improvements in the construction of railways;" being a communication.—4th November 1851.

27. To William Smith, of Upper Grove Cottages, Holloway, in the county of Middlesex, engineer, "improvements in locomotive and other engines, and in carriages used on railways."—4th November 1851.

28. To Robert Hyde Greig, of Manchester, in the county of Lancaster, manufacturer and merchant, and David Bowlas, of Reddish, in the county of Lancaster, manufacturer, "certain improvements in machinery or apparatus for manufacturing weavers' healds or harness;" being a communication.—4th November 1851.

29. To Michael Scott, of John Street, Adelphi, civil engineer, "improvements in punching, rivetting, bending, and shearing metals, and in building ships."—5th November 1851.

30. To Benjamin Hallewell, of Leeds, in the county of York, wine-merchant, "improvements in drying malt."—5th November 1851.

31. To Matthew Gibson, of Wellington Terrace, Newcastle-upon-Tyne, "improvements in machinery for pulverizing and preparing land." —7th November 1851.

32. To William Longmaid, of Beaumont Square, gentleman, "improvements in treating ores and minerals, and in obtaining various products therefrom, certain parts of which improvements are applicable to the manufacture of alkali."—7th November 1851.

33. To Antoine Dominiqu Sisco, of Slough, "improvements in the manufacture of chains, and in combining iron with other metal applicable to such and other manufactures."—11th November 1851.

34. To Frederick Joseph Bramwell, of Millwall, in the county of Middlesex, engineer, "improvements in working the valves of steam-engines for marine and other purposes, and in paddle-wheels."—12th November 1851.

35. To Henry Lund, of the Temple, Esq., "improvements in propelling."—12th November 1851.

36. To William Boggett, of St Martin's Lane, gentleman, and George Holworthy Palmer, of Westbourne Villas, Paddington, civil engineer, "improvements in obtaining and applying heat and light."—14th November 1851.

37. To Henry Richardson, of Aber Hirnaut Bala, North Wales, Esq., "certain improvements in life boats."—14th November 1851.

38. To James Bagster Lyall, of 45 Thurloe Square, Brompton, in the county of Middlesex, gentleman, "an improved construction of public carriage."—14th November 1851.

39. To James Pyke, of Westbourne Grove, Bayswater, in the county of Middlesex, "improvements in the manufacture of leather, also in making boots and shoes."—17th November 1851.

40. To Hugh Bowlsby Willson, of the York Hotel, Blackfriars, in the City of London, Esq., "improvements in the construction of rails for ways."—19th November 1851.

41. To George Tate, of Bantry, in the county of York, gentleman, "improvements in the construction of dwelling houses and other buildings, including carriages and floating vessels, and in the propulsion of such vessels, and in the adaptation and manufacture of materials for such uses."—21st November 1851.

42. To Richard Whytock, of Edinburgh, "improvements in applying colours to yarns or threads and in weaving, or producing fabrics when coloured or party coloured yarns or threads are employed."—24th November 1851.

43. To Thomas Cook, of Preston, in the county of Lancaster, cotton manufacturer, and James Mason, of Preston aforesaid, warper, "certain improvements in looms for weaving."—26th November 1851.

44. To Thomas Cussons, of Bunhill Row, in the county of Middlesex, "improvements in ornamenting woven fabrics for bookbinding and other uses."—26th November 1851.

45. Henry Ellwood, of the firm of Ellwood and Sons, of Great

Charlotte Street, Blackfriars Road, in the county of Surrey, wholesale hat manufacturer, "improvements in the manufacture of hats and other coverings for the head."—26th November 1851.

46. To John Ashworth, of the city of Bristol, manager of the Great Western Cotton Works, "certain improvements in the method of preventing and removing incrustation in steam boilers and steam generators." —26th November 1851.

47. To Jonathan Grindrod, of Birkenhead, in the county of Chester, consulting engineer, "an improvement in the machinery for communicating motion from steam engines or other motive power, and in the construction of rudders for vessels."—1st December 1851.

48. To William Bridges Adams, of 1 Adam Street, Adelphi, in the county of Middlesex, engineer, "certain improvements in the construction of roads and ways for the transit of passengers, of materials, and of goods; also in buildings, and in bridges, and in locomotive engines and carriages, parts of which improvements are applicable to other like purposes."—4th December 1851.

49. To Godfrey Ermen, of Manchester, in the county of Lancaster, cotton spinner, "certain improvements in the method of, and apparatus for, finishing yarns or threads."—8th December 1851.

50. To James Nasmyth, of Patricroft, in the county of Lancaster, engineer, and Robert Minton, of Stoke-upon-Trent, in the county of Stafford, china manufacturer, "certain improvements in machinery or apparatus to be employed in the manufacture of tiles, bricks, and other articles from disintegrated or pulverised clay."—11th December 1851.

51. To Frederick William Norton, of Paisley, in the county of Renfrew, North Britain, manufacturer, "certain improvements in the manufacture or production of plain and figured fabrics."—12th December 1851.

52. To John Livesey, of New Lenton, Nottingham, draughtsman, "improvements in the manufacture of textile fabrics, and in machinery for producing the same."—15th December 1851.

53. To John Cumming, of Paisley, in the county of Renfrew, North Britain, pattern designer, "improvements in the production of surfaces for printing or ornamenting fabrics."—15th December 1851.

54. To Herman Schroeder, of Bristol, gentleman, "improvements in manufacturing and refining sugar, which improvements are applicable to evaporating other fluids where a low temperature is advantageous."— 22d December 1851.

55. George Gwynne, of Hyde Park Square, in the county of Middlesex, Esq., and George Fergusson Wilson, managing director of Price's Patent Candle Company, of Belmont, Vauxhall, "improvements in treating fatty and oily matters, and in the manufacture of lamps, candles, night lights, and soap."—22d December 1851.

Erratum.—At page 328 of Vol. LI. of Journal, for account given by Mr Monk, *read* by the author of the "Crescent and the Cross."

THE
EDINBURGH NEW
PHILOSOPHICAL JOURNAL.

Account of the Observations which have revealed to us the Physical Constitution of the Sun, and that of different Stars: Examination of the Conjectures of the Ancient Philosophers; and of the Positive Data of Modern Astronomers, concerning the Place in which the Sun should be considered among the vast number of Stars with which the Firmament is strewed.

By M. ARAGO.*

ABOUT the middle of last July, astronomers from the principal observatories of Europe repaired to Norway, Sweden, Germany, and Russia, locating themselves in those towns where the eclipse of the sun on the 28th of that month would be total. They expected that this phenomenon, studied with powerful instruments, would lead to satisfactory explanations of different appearances observed in previous eclipses, and upon which no one had ventured definitely to give an opinion. What! may exclaim some fretful individuals, who are little acquainted, I suspect, with the history of Astronomy; what! does the science regarded the most perfect still supply problems for resolution; and even concerning the luminary around which all the planets revolve? Is it true, that, in many respects, we are not more advanced than were the philosophers of ancient Greece?

It has been conceived that these questions should be taken into serious consideration. And I have undertaken to prepare the response, not forgetting how uninteresting it may prove, and that details now become elementary will come prominently into view; but I trust that your indulgence will not be withheld from him who is fulfilling a duty.

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* Read at the Annual Public Meeting of the Five Academies of the French Institute, 25th October 1851.

A general glance at the works of ancient philosophers and modern observers, will prove at once that if the sun has been studied for two thousand years the prospect has often changed, and that during this period the science has made immense advances.

Anaxagoras maintained that the sun was scarcely larger than the Pelopennesus.

Eudoxius, who was so much esteemed among the ancients, assigned to the sun a diameter nine times greater than that of the moon. This was a great advance, when compared with the statement of Anaxagoras. But the number given by the philosopher of Gnidus is still immensely short of the truth.

Cleomidus, who wrote in the reign of Augustus, says that his contemporaries the Epicureans, trusting to appearances, held that the real diameter of the sun did not exceed a foot.

Let us compare these arbitrary calculations with the conclusion deducible from the works of modern astronomers, executed with the most minute care, and with the assistance of instruments of extreme delicacy. The diameter of the sun is 883,000 miles; widely different, as every one will perceive, from that stated by the Epicureans.

Supposing the sun to be spherical, its volume is 1,400,000 times that of the earth. Such enormous numbers not being often used in common parlance, and not conveying an exact idea of the magnitude they imply, I shall here employ an illustration which will enable us better to appreciate the immensity of the sun's volume. Imagining, for a moment, that the centre of the sun corresponded to that of the earth, its surface would not only reach the sphere in which the moon revolves, but it would extend almost as far again.

These results, so extraordinary in their immensity, have the certainty of the elementary principles of geometry on which they are based.

My subject being so extensive, I shall not in detail institute a comparison between the results—truly absurd from their insignificancy—at which the ancients had arrived regarding the distance between the sun and the earth, and those which modern observations have deduced. I shall even limit myself to remark that it is demonstrated—and I use this positive term advisedly—that it is demonstrated, since the transit of Venus in 1769, that the mean distance from the sun to the earth is 95 millions of miles, and that between summer and winter the sun removes itself from us more than three million of miles. Such is the distance of the immense globe whose physical constitution modern astronomers have succeeded in determining.—We find nothing in the works of ancient philosophers on this subject, which merits a moment's consideration.

Their disputes as to whether the sun is a pure or impure, an extinguishable or unextinguishable fire, not being supported by any observation, left in profound obscurity the problem which the moderns have tried to solve.

The progress which has been achieved in this inquiry, dates from 1611. At this epoch, little removed from that of the invention of the telescope, Fabricius, a Dutch astronomer, saw black spots distinctly exhibited on the eastern margin of the sun, which moved gradually towards the centre, passed it, reached the western margin, and then disappeared for a certain number of days.

From these observations, frequently since repeated, this conclusion may be deduced, that the sun is a spherical body, endowed with a rotatory motion, whose duration is equal to twenty-five and a half days.

These black spots are irregular and variable, but well-defined towards their circumference; they are sometimes of considerable dimensions, some having been seen five times the size of the earth; they are generally surrounded with a radiance perceptibly less luminous than the rest of the orb, and which has been named *penumbra*. This penumbra, first noticed by Galileo, and carefully observed by his astronomical successors in all the changes which it undergoes, has led to a supposition, concerning the physical constitution of the sun, which at first must appear altogether astonishing.

According to this view the orb would be regarded as a dark body, surrounded at a certain distance by an atmosphere which might be compared to that enveloping the earth when composed of a continuous bed of opaque and reflecting clouds. To this first atmosphere would succeed a second, luminous in itself, and which has been called *photosphere.* This photosphere, more or less removed from the interior cloudy atmosphere, would determine by its circumference the visible limits of the orb. According to this hypothesis, spots upon the sun would appear as often as there were found in the two concentric atmospheres corresponding vacant portions, which would permit us to see exposed the dark central body.

Those who have studied these phenomena with powerful instruments, professional astronomers, and competent judges, acknowledge that the hypothesis of which I have just spoken, concerning the physical constitution of the sun, supplies a very satisfactory account of the facts. Nevertheless, it is not generally adopted; recent authoritative works describe the spots as scoriæ floating on the liquid surface of the orb, and issuing from solar volcanoes, of which terrestrial volcanoes are but a feeble type.

It was desirable, then, to determine, by direct observation, the nature of the incandescent matter of the sun.

But when we consider that a distance of 95 millions of miles separates us from this orb, and that the only means of communication with its visible surface are luminous rays emanating therefrom, even to propose this problem seems an act of unjustifiable temerity.

The recent progress in the science of optics has, however, furnished the means for completely solving the problem. My readers will pardon some necessary details which will render its solution evident.

None are now ignorant that natural philosophers have succeeded in distinguishing two kinds of light, viz., natural and polarized. A ray of the former of these lights exhibits, on all points of its surface, the same properties; whilst, with regard to the polarized light, the properties exhibited on the *different* sides of its rays are different. These discrepancies manifest themselves in a multitude of phenomena which need not here be noticed.

Before going further, let us remark that there is something wonderful in the experiments which have led natural philosophers legitimately to talk of the different sides of a ray of light. The word "wonderful" which I have just used, will certainly appear natural to those who are aware that millions of millions of these rays can simultaneously pass through the eye of a needle without interfering the one with the other.

Polarized light has enabled astronomers to augment the means of investigation by the aid of some curious instruments, from which great benefit has accrued already,—amongst others, the polarizing telescope, or polariscope, merits attention.

In looking directly at the sun with one of these telescopes, two white images of the same intensity and the same shade will be seen. Let us suppose the reflected image of this orb to be seen in water or in a glass mirror. In the act of reflection the rays become polarized, the lens no longer presenting two white and similar images; on the contrary, they are tinged with brilliant colours, their shape having experienced no alteration. If the one be red, the other will be green; if the former be yellow, the latter will present a violet shade, and so on; the two colours always being what are called complementary, or susceptible, by their mixture, of forming white. By whatever means this polarized light has been produced, the colours will display themselves in the two images of the polarizing telescope, as when the rays have been reflected by water or by glass.

The polarizing telescope, then, furnished a very simple means of distinguishing *natural* from polarized light.

It has been long believed that light emanating from incandescent bodies reaches the eye in the state of natural light, when it has not been partially reflected, nor strongly refracted, in its passage.

The exactitude of this proposition failed, however, in certain points. A member of the Academy has succeeded in discovering that the light emanating under a sufficiently small angle, from the surface of a solid or liquid incandescent body, even when unpolished, presents evident marks of polarization; so that in passing through the polarizing telescope it is decomposed into two coloured pencils.

The light emanating from an inflamed gaseous substance, such as that which now-a-days illuminates our streets and our shops, on the contrary, is always in its natural state, whatever may have been its angle of emission.

The means used to decide whether the substance which renders the sun visible is solid, liquid, or gaseous, will be nothing more than a very simple application of the foregoing observations, in spite of the difficulties which appeared to flow from the immense distance of the orb.

The rays which indicate the margin of the disc have evidently issued from the incandescent surface under a very small angle. The question here occurs: The margins of the two images, which the polarizing telescope furnishes, do they, when viewed directly, appear coloured?—then, the light of these margins proceeds from a liquid body; for any theory which would make the exterior of the sun a solid body is definitively removed by the observation of the rapid changing of the form of the spots. Have the margins maintained their natural whiteness in the glass? then they are necessarily gaseous.*

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* The incandescent bodies which have been studied by a polariscope, the light being emitted under different angles, are the following:—Of solids, forged iron and platina; of liquids, fused iron and glass. From these experiments it may be said, you have a right to affirm, that the sun is neither fused iron nor glass; but what authority have you further to generalize? My response is this: Following the two explanations which have been given of the abnormal polarization which presents rays emitted under acute angles, all ought to be the same, with the exception of the quantity, whatever be the liquid, provided that the surface of emergence has a sensible reflecting power. There would remain only the case in which the incandescent body would, as to its density, be analogous to a gas; as, for example, the liquid of an almost ideal rarity, which many geometricians have been led to place hypothetically at the extreme limit of our atmosphere, where the phenomena of polarization and of colorization may perhaps disappear. I am not ignorant that I should add a value to the experiment reported in the text by discussing it in a photometrical point of view. I possess the materials for such an examination, but this is not the place for pursuing it.

I shall, however, anticipate a difficulty which may suggest itself. It ought to

Observations made any day of the year, looking directly at the sun, with the aid of powerful polarizing telescopes, exhibit no trace of colorization. The inflamed substance, then, which defines the circumference of the sun, is gaseous. We can generalize this conclusion, since, through the agency of rotation, the different points of the surface of the sun come in succession to form the circumference.

This experiment removes out of the domain of simple hypothesis the theory we have previously indicated concerning the constitution of the solar photosphere. We assuredly find, neither in the arbitrary conceptions which are the results of the brilliant imagination of the ancient philosophers of Greece, nor in the extant works of the most celebrated astronomers of the Alexandrian school, any thing which, even by a forced assimilation, can be compared to the results which I have just advanced. These results, let it be loudly proclaimed, are entirely due to the united efforts of the observers of the seventeenth and eighteenth centuries, and also in a certain measure to those of our contemporary astronomers.

And here let me make a remark, which, when endeavouring to determine the physical constitution of the stars, we shall have occasion to apply.

If the material of the solar photosphere were liquid, if the rays emitted from its margin were polarized, the two images furnished by the polarizing telescope would not only be coloured, but they would be different in the different parts of the circumference. Is the highest point of one of these images red, the point diametrically opposite will be red also. But the two extremities of the horizontal diameter will each exhibit a green tint, and so on. If, then, one succeeds in con-

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be observed, that the lights proceeding from two liquid substances, may, according to the special nature of these substances, not be identical in reference to the number and the position of the black bands of Fraunhofer, and which their prismatic hues offer to the eye of the philosopher.

These discrepancies are of a nature to be considerably augmented by the differently-constituted atmospheres through which the rays have to travel before reaching the observer.—(*This note was not read at the public meeting of the 25th of October.*)

centrating to a single point the rays emitted from all parts of the sun's limb, even after their decomposition in the polarizing telescope, the mixture will be white.

The constitution of the sun, as I have just established it, may equally well serve to explain how, on the surface of the orb, there exist some spots not black but luminous. These have been called faculæ. Galileo was the first to observe them. The others, of much smaller dimensions, and generally round, were discovered by Scheiner, and by him named lucules. These latter cause the surface of the sun to appear spotted.

It is a singular fact; but I might trace the origin of the discovery of one of the principal causes of the *faculæ* and lucules to an administrative visit to a shop of novelties situated on our boulevards.

"I have to complain," said the master of the establishment," of the Gas Company; it ought to direct on my goods the broad side of the bat-wing burner, whilst, by the carelessness of their servants, it is often the edge which is directed on them." "Are you certain," said one of the assistants, "that in that position the flame gives less light than in the other?" The idea appearing ill-founded, and, I would even say, absurd, it was submitted to accurate experiment; and it was determined that a flame shed upon any object as much light when it illuminates by its edge as when its broad surface was presented to it.

Thence resulted the conclusion, that a gaseous incandescent surface of a determined extent is more luminous when seen obliquely than under the perpendicular incidence. Consequently, if, like our atmosphere, when dappled with clouds, the solar surface presents undulations, the parts of these undulations which are presented perpendicularly to the observer must appear comparatively dim, and the inclined portions must appear more brilliant; and hence every conic cavity must appear a lucule. It is no longer necessary in accounting for these appearances, to suppose that there exist on the sun millions of fires more incandescent than the rest of the disc, or millions of points distinguishing themselves from the neighbouring regions by a greater accumulation of luminous matter.

After having proved that the sun is composed of a dark central body, of a cloudy-reflecting atmosphere, and of a photosphere, we should naturally ask if there is nothing besides; if the photosphere terminates abruptly and without being surrounded by a gaseous atmosphere less luminous in itself, or feebly reflecting? Generally, this third atmosphere would disappear in the ocean of light with which the sun always appears surrounded, and which proceeds from the reflexion of its own rays upon the particles of which the terrestrial atmosphere is composed.

A means of removing this doubt presented itself; it was selecting the moment wherein, during a total eclipse, the moon completely obscures the sun.

Almost at the moment when the last rays, emanating from the margin of the radiant orb, disappeared under the opaque screen formed by the moon, our atmosphere, in the region which is projected between the moon, the earth, and the neighbouring parts, ceased to be illuminated.

Every one now knows what was the principal object of the astronomers, who in 1842 repaired to the south of France, to Italy, to Germany, and to Russia, where the eclipse of the sun of the 8th of July would be total.

In all our researches, innumerable unexpected appearances invariably present themselves: thus the observers were not a little surprised when, after disappearance of the last direct rays of the sun behind the margin of the moon, and after the light reflected by the surrounding terrestrial atmosphere had also disappeared, to see rose-shaped prominences from two to three minutes in height, dart, as it were, from the circumference of our satellite.

Each astronomer, following the usual bent of his own ideas, arrived at an independent opinion regarding the cause of these appearances. Some attributed them to the mountains of the moon; but this hypothesis would not bear a moment's examination. Others wished to discover in them certain effects of diffraction or of refraction. But the touchstone of all theories is calculation; and uncertainty the most indefinite must follow, in reference to their application to the remarkable phenomena specified, those, namely, of which we have just been speaking. Explanations giving neither an exact account of the height, the form, the colour, nor the fixity of a phenomenon, ought to have no place in science.

Let us come to the idea, much extolled for a short time, that the protuberances of 1842 were solar mountains, whose summits extended beyond the photosphere covered by the moon at the moment of observation.

Following the most moderate computations, the elevation above the solar disc of one of these summits, would have been 19,000 leagues. I am well aware that no argument, because based on the vastness of this height, should lead to the rejection of the hypothesis. But it may be much shaken by remarking, that these pretended mountains exhibit considerable portions beyond the perpendicular, which, consequently, in virtue of the solar attraction, must have fallen down.

Let us take a rapid glance of a fourth hypothesis, according to which the protuberances would be assimilated to solar clouds floating in a gaseous atmosphere.

Here we find no principle of natural philosophy to prevent our admitting the existence of cloudy masses from 70,000 to 90,000 miles in length, with their outline serrated, and assuming the most distorted forms. Only in further pursuing this hypothesis, one could not fail to be astonished that no solar cloud had ever been seen entirely separated from the circumference of the moon.

It is towards this determination, the subject otherwise eluding us, that the researches of astronomers should be directed.

A mountain being incapable of sustaining itself without a base, the fortuitous observation of a prominence, separated in appearance from the margin of the moon, and, consequently, from the real margin of the solar photosphere, should be sufficient utterly to overthrow the hypothesis of solar mountains.

But let it be distinctly remarked, that it is not with astronomical researches as with those of chemists and mechanical philosophers; these latter can at will vary the conditions *under* which they operate, and which may change the nature of the results. But astronomers exercise no influence over the phenomena which they study; they are obliged to wait sometimes for centuries until the celestial bodies present themselves in a favourable position for the resolution of a difficulty.

On this occasion, however, the doubts raised by the observations of 1842 have already, in the course of last year, been subjected to a new experimental examination. An eclipse of the sun was announced to occur on the 8th of August 1850, which was to be total in the Sandwich Islands.

The captain of the ship Bonnard, commanding our station of Otaheite, entertained the happy thought of sending M. Kutscki, superintendent of roads and bridges, to Honolulu, in the island of Taheite, the capital of the Sandwich Archipelago.

The account which we have received from this skilful observer, contains the following sentence:—"The slender and reddish striated appearance which was found near the northern prominence seemed to be completely detached from the margin of the moon."

Still later, in the eclipse of 28th July 1851, Messrs Mauvais and Goujon of Dantzic, and the celebrated foreign astronomers who had repaired to different parts of Norway, Sweden, and the north of Germany, saw in all the selected stations without exception, a spot uniformly red and separated from the limb of the moon.

The observation of M. Kutscki, and the corresponding observations of 1851, put a definite termination to the explanations of the protuberances, founded on the supposition that there existed in the sun mountains whose summits would reach considerably above the photosphere.

When it shall have been clearly demonstrated that these luminous phenomena cannot be the effect of the inflexions which the solar rays might experience in passing near the rough parts which fringe the circumference of the moon; when it shall have been demonstrated that these rosy tints cannot be assimilated to simple optical appearances, and have, in truth, a real existence, that they are not real solar clouds, it will then be necessary to add a new atmosphere to the two of which we have just spoken; for these clouds cannot be sustained *in vacuo*.*

Every one now knows the uncertainty which still remains upon one point, truly remarkable, concerning the physical constitution of the sun. When we think that the phenomena which might decide all doubts are habitually invisible, that they can only be seen during total eclipses of the sun, which total eclipses are of rare occurrence, so much so, that since the invention of telescopes the astronomers of Europe and America have scarcely had an opportunity satisfactorily to observe six; no one will be astonished that in the middle of the nineteenth century the question raised by the mysterious red flames upon which so much has been said, still remains to be investigated.

After these explanations, the length of which I must beg you to excuse, we shall indicate, in a few words, by what series of measurements and deductions, science has succeeded in fixing the true place of the sun in the totality of the universe.

Archelaus, who lived in the year 448 B.C., was the last philosopher of the Ionian sect; he said, regarding the sun,—

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* That these clouds may be sustained *in vacuo*, it is necessary that the centrifugal force resulting from their circular movement shall incessantly equal the gravitation which would cause them to fall towards the sun. One would need to transform them into real planets, revolving with extreme rapidity around the sun. Such, in substance, is the explanation of the prominences of 1842, which M. Babinet has given at the meeting of the Academy of Sciences on the 16th of February 1846.

The reader will perceive, in the memoir of the learned Academician, the ingenious considerations upon which this theory is based, and how analogous it is to the cosmogonic system of Laplace. I think, now that the phenomenon has been minutely observed, that M. Babinet will find more than one difficulty in reconciling the immense velocity which he is compelled to attribute to the matter of the prominences, with the relative immobility of those which have been observed in 1851, and the change of height which they have presented. These difficulties will no longer exist when the spots are assimilated to clouds floating in a solar atmosphere, endowed with a slight rotatory movement.

I would, moreover, remark, that the existence of this third atmosphere is established by phenomena quite of another nature, namely, by the comparative intensity of the border and the centre of the sun, and also in some respects by zodiacal light, so perceptible in our climate during the equinoxes. But the question, considered from this point of view, requires details from which I am forced to abstain.

"It is a star, only it surpasses in size all the other stars." The conjecture, for what is not based upon any measurement, or any observation, deserves no other name, was certainly very bold and very beautiful. Let us pass over an interval of more than two thousand years, and we shall find the relation of the sun and the stars established by the labours of the moderns, upon a basis which defies all criticism.

During nearly a century and a half, astronomers endeavoured to determine the distance between the stars and the earth; the repeated failures with which their researches were attended, seemed to prove that the problem was insolvable. But what obstacles will not genius, united to perseverance, overcome? We have discovered within a very few years the distance which separates us from the nearest stars. This distance is about 206,000 times the distance of the sun from the earth, more than 206,000 times 95 millions of miles. The product of 206,000 by 95 millions, would be too much above the numbers we are in the habit of considering, to warrant its annunciation.

This product will still more strike the imagination, when I refer to the rapidity with which light travels. Alpha, in the constellation of the Centaur, is the star nearest the earth, if it be allowable to apply the word near to such distances as those of which I am about to speak.

The light of Alpha, of the Centaur, takes more than three years to reach us, so that were the star annihilated, we should still see it for three years after its destruction. Recal to your recollection that light travels at the rate of 192,000 miles in a second; that the day is composed of 86,400 seconds, and the year of 365 days, and you will feel as thunderstruck before the immensity of these numbers. Furnished with these data, let us transport the sun to the place of this, the nearest star, and the vast circular disc, which in the morning so majestically rises above the horizon, and in the evening occupies a considerable time in descending entirely below the same line, would have dimensions almost imperceptible, even with the aid of the most powerful telescopes, and its brilliancy would range among the stars of the third magnitude. You thus perceive what has become of the conjecture of Archelaus.

One may perhaps feel humiliated by a result which reduces so far our position in the material world; but consider that man has succeeded in extracting everything from his own resources, whereby he is elevated to the highest rank in the world of thought. Astronomical examinations, then, might almost excuse, on our part, some little vanity.

But I must not follow modern astronomers in their immortal peregrination through the multitude of suns which shine in the firmament.

We must first, then, see to determine, with the help of their instruments, the relative position of these stars, cataloguing a hundred thousand of them; we know that Pliny the elder was astonished that Hypparchus had tried to observe 1022, and compared it to the work of a god.

We would remark, that in recent works of complete astral catalogues, we shall find that the number of stars visible to the naked eye in a single hemisphere, namely, the northern, is under three thousand. A certain result, and one which, notwithstanding, will strike with astonishment, on account of its smallness, those who have only vaguely examined the sky on a beautiful winter night.

The character of this astonishment will change, if we proceed to the telescopic stars. Carrying the enumeration to stars of the fourteenth magnitude, the last that are seen by our most powerful telescopes, we shall find by an estimate which will furnish us the minior limit, a number superior to 40 millions (40 millions of suns!!), and the distance from the farthest among them is such, that the light would take from three to four thousand years to traverse it.

We are, then, fully authorised to say, that the luminous rays—these rapid couriers—bring us, if I may so express it, the very ancient history of these distant worlds.

A photometric experiment, of which the first indications exist in the Cosmotheoros of Huygens, an experiment resumed by Wollaston a short time before his death, teaches us that 20,000 millions of stars the same size as Sirius, the most brilliant of the firmament, would need to be agglomerated to shed upon our globe a light equal to that of the sun.

Guided by the penetrating genius of William Herschel, we shall examine the stars which nearly touch each other; and this great astronomer will prove to us, that these stars which are in some way coupled together, do not appear near each other solely by the effect of perspective, but that they are in a state of mutual dependence, and circulate round their common centre of gravity in a short time, which, in certain cases, has been already determined.

In observing that these double stars are of very dissimilar colours, our thoughts naturally turned to the inhabitants of the obscure and revolving planetary bodies which apparently circulate round these suns; and we would remark, not without real anxiety for the works, the paintings, of the artists of these distant worlds, that to a day lightened by a red light, succeeds not a night but a day, equally brilliant, but illuminated only by a green light.

The comparison of the positions of the stars determined at different epochs, proves that they have very erroneously been called *fixed;* that they move in space in different ways, so that in the long-run the present form of the constellations will be completely changed; that the absolute speed of these stars is unequal, but that it has been ascertained, with regard to one of them, with complete certainty, that it moves 20 leagues per second; that the sun, in this respect resembling all the other stars, is not immoveable, and draws after it the train of planets with which it is surrounded.

We must be struck with the inequality of the distribution of the stars in the celestial sphere. There, we see more than 20,000 of them in a superficial space equal to the tenth part of the apparent surface of the moon; here, in a space of the same extent, not a single luminous speck will be perceptible, even with the best telescopes.

After having carefully glanced over the luminous matter scattered over such immense spaces, and which by its agglomeration, continued during centuries, seems to have produced new stars, we would discuss the vast ideas of Wright, Kant, Lambert, and William Herschel, upon the constitution and dimensions of the milky way. In short, some additional steps in astronomical conjecture, that is to say, in that branch of science founded only on imposing probabilities and natural generalizations, will unveil phenomena, which, by their nature, or the immensity of the numbers which measure them, will throw the most firm minds into a sort of vertigo.

But abandoning these speculations, however worthy they may be of admiration, we shall come back to the chief question which I have proposed to treat in this account,—to try, if possible, to establish a connection between the physical nature of the sun and of the stars.

We have succeeded, by the help of the polarizing telescope, to determine the nature of the substance which composes the solar photosphere, because by reason of the great apparent diameter of the orb we have been able to observe separately the different points of its circumference. If the sun were removed from us to a distance where its diameter would appear as small to us as that of the stars, this method would be inapplicable. The coloured rays proceeding from the different points of the circumference would then be intimately mixed, and, we have said already, that their mixture would be white.

It appears, then, that we must not apply to stars of imperceptible dimensions the process which so satisfactorily conducted us to the result in regard to the sun. There are, however, some of these stars which supply us with the means of investigation. I allude to the changing stars.

Astronomers have remarked some stars whose brilliancy varies considerably; there are even some which, in a very few hours, pass from the second to the fourth magnitude; and there are others amongst which the changes in intensity are much more decided. These stars, quite visible at certain epochs, totally disappear, to reappear in periods longer or shorter, and subject to slight irregularities.

Two explanations of these curious phenomena present themselves to the mind; the one consists in supposing that the star is not equally luminous on all parts of its surface, and that it experiences a rotatory movement upon itself; thus it is brilliant when the luminous part is turned towards us, and dark when the obscure portion arrives at the same position.

ccording to the other hypothesis, an opaque, and, in itself, non-luminous satellite, circulates round the star and eclipses it periodically.

In accordance with one or other of these suppositions, the light which is exhibited some time before the disappearance or before the reappearance of the star has not issued from all the points of the circumference. Hence, there can be no doubt of the complete neutralisation of the tints of which we have just spoken.

If a changing star, when examined by a polarizing telescope, remains perfectly white in all its phases, we may rest assured that its light emanates from a substance similar to our clouds, or our inflamed gas. Now, such is the result of the few observations that have hitherto been made, and which it will be highly useful to complete. This means of investigation demands more care, but succeeds equally well, when applied to those stars which experience only a partial variation in their brilliancy.

The conclusion to which these observations conduct us, and which we may, I think, without scruple generalise, may be announced in these terms: Our sun is a star, and its physical constitution is identical with that of the millions of stars with which the firmament is strewed.

I have thus endeavoured, according to the plan which was previously assigned me, to give a sketch of all that we now know relative to the volume, the distance, and the physical constitution of the immense globe whence we derive our light. This sketch, in its circumscribed limits, will suffice to undeceive those who thought it a duty to call in question the importance and the certainty of the results obtained by modern observers.

If candid, they will recognise, that, in the history of the progress of our knowledge—a progress undoubtedly indefinite—the labours of the astronomers of the nineteenth century will not pass unnoticed.

As to critics, who have not been inspired by a love of truth, they do not merit a moment's attention from this assembly; and as for myself, I cannot but despise them.

I.

Opening of the Government School of Mines, and of Science as applied to the Arts.

This important National Establishment was lately opened by Sir Henry de la Beche, C.B., F.R.S., &c., the Director-General, and its main founder, in an Inaugural Discourse, in which he gave a lucid and interesting account of its nature and objects. He mentioned the following as the branches of knowledge to be taught, viz., Chemistry, Natural History applied to Geology, Mechanical Science, Geology, Metallurgy, Mineralogy, and Mining, by means of a staff of able and distinguished Professors, who have at their command an extensive and very valuable Museum of Practical Geology, with complete and amply-furnished Chemical Laboratories, an Office of Mining Records and of Geological Surveys. That Sir Henry has been fortunate in the selection of Professors is shewn by the names in the programme of the School.

II.

Copies of several of the Introductory Lectures delivered in the Museum of Practical Geology of the School of Mines have reached us. We now lay before our readers one of these, as a specimen of the style of lectures delivered in this promising establishment. It is the excellent lecture of our distinguished friend and former pupil, Professor Edward Forbes, "*On the Relations of Natural History to Geology and the Arts.*"

"Natural History is a vast and continually-extending science. It embraces Zoology, Botany, and much of Geology. The sections of it are subdivided into studies, each of which, if pursued to its full development, would more than occupy a lifetime. No single man can, in the present state of knowledge, grasp the details of all the natural history sciences, or even of one of their great sections. But the principles that pervade all are the same. The same laws govern the animal and vegetable kingdoms. The same laws regulated the phenomena of animal and vegetable life through the geological past that now regulate them in the historical present. That such is true, is for the naturalist to demonstrate. The zoologist, the botanist, and the geologist contribute the elements of the demonstration, but the great pervading principles of the entire science demand a combined study of the three kingdoms of nature. The task assigned to me in this Institution is the exposition of these principles; their illustration, by examples drawn from existing and extinct forms of *life;* and the teaching of such details of zoology and botany, recent and fossil, as are necessary to the accurate conduct of geological research, and have thereby a practical and economic bearing, through the certainty they give to geological determinations. A second and distinct duty, hereafter to be performed, will be the illustration of the application of natural history knowledge to the arts and manufactures.

Of all the departments of the educational system adopted in this Institution, mine is apparently the least practical. The chemist, the metallurgist, the mechanician, come directly into contact with the arts and their votaries. The miner furnishes the materials from which so much of the riches of England is derived. The geologist investigates the structure of the country, and thus gives certainty to the operations of the engineer, develops new sources of mineral and agricultural wealth, and prevents the expenditure of capital in wrong directions. All men understand why the manufacturer and artisan are indebted to the chemist and metallurgist, whose obligations to the miner and the geologist are too evident not to be freely acknowledged by themselves and those who benefit by their pursuits. But the naturalist seems to work apart from practical men. His duties are performed behind the scenes, and make no conspicuous show. His share in the work can be fully appreciated only by the geologist, whose requirements necessarily lead him into the palæontological laboratories. Like a labourer among the foundations of an edifice, he is unseen by the crowd who admire the beautiful superstructure, though without his labour the building would be unsafe and incomplete. It needs but a brief argument to prove this to an intelligent audience.

That geology is an essential element of a scientific mining education is obvious at first thought. That natural history should be, may not seem so evident to persons as yet unversed in geology. That palæontology is an essential element of geological science, no one who is acquainted with the rules by which the relative ages of sedimentary rocks are determined will deny. And that palæontology, apart from natural history, is empirical and false, and has no claims to the dignified title of science, every intelligent student of organic remains will maintain. Therefore, the teaching of the study of fossils in this Institution is to be conducted with constant reference to, and comparison with, living organisms; for by no other method can we hope to gain an insight into the history of the manifestations of life during the geological past, such as is necessary for the truly scientific, and, consequently, *safely practical*, study of geological science and its applications.

The value of natural history as an educational science has been but partially recognised in Britain. In our schools and colleges, the chief cultivation has been directed to the nurture and training of the memory, the reasoning powers, and taste; not always by the most judicious methods. Observation, a faculty upon the correct exercise of which the value of the others in a great measure must depend, has been neglected or even entirely ignored. Yet to observe truly, to note accurately, are surely qualities of essential importance to the wellbeing and future prospects of every youth. The successful progress of a man through life, the weight attached to his statements, must, in a great measure, depend upon them. The simplest, easiest, and most beneficial method of cultivating the observing powers lies in the acquirement of the methods and practice of the natural history sciences. Ignorance alone could have excluded them from recognised courses of education. Though partly taught in some of our universities, it is as branches of knowledge usually in connection with the enlightened profession of medicine, and not on account of their value in educational training. Of late, however, there has been a tendency to rectify this. Oxford and Cambridge have recognised, in theory at least, the right of natural history to share in their honours. Their younger sister, London, with the timidity of youth, has hesitated to pronounce in its favour. [illegible] universities of Scotland and Ireland, the [illegible]litan colleges, and the [illegible] history sciences are taught by able professors; but the total num[illegible] unprofessional disciples is small, and cannot be said to be increasing. [illegible] schools of lesser grade they assume, when professed to be taught [illegible] the form of intellectual recreations; not that of exercises, and strengtheners of the mind of the pupil. The time, I trust, will yet come when every student will be required to educate his observing powers through the agency of these delightful branches of study.

The earliest efforts of infant intellect are directed towards the observation of natural objects. Animals, plants, minerals, are collected by the schoolboy, who delights to note their shape and qualities, and rudely to compare and classify. But the thirst for natural knowledge thus early and unmistakeably manifested, is rudely quenched by unpalatable draughts of scholastic lore, administered too often by a tastless pedagogue, who, blind to the indications of a true course of education, thus plainly pointed out by human nature, developing itself according to the laws of its own God-given constitution, prunes and trims, binds and cramps, the youthful intellect into traditional and fantastic shapes; even as the gardeners of a past age tortured shrubs and trees into monstrous outlines, vainly fancying to improve their aspect, arresting the growth of the spreading boughs and the budding of the clustering foliage, mistaking an unhealthy formality for beauty. Far be it from me to disparage the educational value of the glorious literature of Greece and Rome, or to withhold due honour from the many able and learned men who give dignity to their profession as educators. To them I would appeal for the rectifying of the evils of a one-sided education. I would implore them, in the name of Aristotle, the greatest of naturalists, and most admirable of observers—how great otherwise none know better than they do—to avail themselves of that science upon which he laid so much stress, and through it to cultivate those tracts of the mind of youth that now lie fallow and unproductive.

I speak thus strongly respecting the neglect of the sciences of observation in the ordinary practice of education in England, because it is too probable that in it lies one of the chief difficulties with which schools of applied sciences will have to contend in the outset. The rudiments of science should be taught elsewhere. The student should come prepared with a groundwork of elementary training, which there is too much reason to fear, in the present condition of schools and schoolmasters, he will have great difficulty in obtaining. The training for scientific study should be effected in preparatory schools. The teaching here should consist in the communication of scientific knowledge, and in the elucidation of the applications of it. But we do not despair. The events of this year have gone far to awaken Englishmen to the consciousness of the dignity that is inherent in those pursuits which have made their country so powerful among nations. The union of practice with science is the surest way to keep her strong position. Through the operation of well-devised educational establishments only can that union be cemented, and future results secured.

In the scheme of education adopted by the School of Mines, it will be observed that palæontology is regarded as inseparable from natural history. I have already said that the study of organic remains, conducted independently of the study of living organisms, is essentially empirical and injurious to science. The value, the interest, the scientific and practical importance of fossils, depend entirely on the knowledge of their true nature, which we gain through a comparison of them with their existing homologues and analogues. That comparison cannot be understood unless we make ourselves acquainted with the habits and organisation of the living types with which fossils must be compared. There are now nearly 30,000 kinds of fossils known and described; these have been discovered in formations of all epochs. Some of them are the remains of beings that lived at immeasurable distances of time,—some of them are the skeletons of creatures that flourished along with the ancestors of species now existing. Yet all researches hitherto made have gone to shew that every form of extinct life was a member of the same great series of beings with those which now inhabit our world,—that the laws of organisation and the laws of life were the same in the primeval epochs of Preadamite time as now,—that the same great universal thought has uniquely pervaded the one great creative action,—that the repeated manifestations of creative power during successive ages have ever announced the one consistent idea.

It is not an uncommon fancy to suppose that naturalists are occupied entirely with the naming and describing of the kinds of anima and plants; that, provided they can enumerate in clear though technical language the characteristics or features of a being submitted to their examinations, usually in the state of a preserved specimen, and, on discovery of the species being one hitherto unnoticed, give it a name by which it may be remembered by their brother naturalists to the end of time, or thereabouts, they have attained all their aim, and fulfilled all their ambition. This notion of their duties and offices is a libel. It takes note of only a fragment of their labours. To name and describe are but to enrol an object, with a true spelling and clear definition, in the great dictionary of science. Words in dictionaries are exhibitions of the raw materials out of which literature is made; and species arranged in zoological and botanical systems are orderly and beautiful displays of the raw materials of natural history science. Words may be wasted, and species misused. But the study of species, which is the basis of all natural history science, does not take note merely of their external or even their internal organisation. It deals also with their relations to conditions in time and space. It seeks out the epoch of their first appearance, and traces them through their diffusion under favouring, or limitation and final extinction under unfavourable influence. It searches for the causes inherent to their organisation, by which, of two similar yet not identical creatures, the one has the power to battle with varied and very different forces, to maintain a vitality that braves the duration and complicated arrangements of several successive epochs, and, daring alike the freezing cold of the poles and the feverish warmth of the equator, to spread its individuals over more than half the world. Whilst the other, distinguished, it may be, from its congener by some apparently slight and useless difference,—though the mark be an indelible brand by which nature has stamped that member of her flock, and that only one,—is incapable of assuming protean variations, or of enduring a slight change in the physical conditions under which it first appeared. It enjoys a fleeting existence during a short segment of time; dies out ere it has spread beyond a mere speck on the earth's surface, disappearing never to reappear;—perchance, if it belonged to some primeval auna, never to become known to man, with all his research, unless ome bony or shelly framework gave consistence to its otherwise erishable substance.

But so to deal with our subject, so to work at natural history, ow can we proceed without the aid of geology? It is plainly impossible. From the moment we recognise a consideration of the elation to time and space of species and genus, as an essential elenent of a right and full understanding of them, from that moment he naturalist calls in geology to his aid. And how is geology to elp him? The pure geologist,—the inquirer into the earth's physical features at the different stages of its eventful history, and into he probable nature of its internal constitution and the causes of the equalities of the outline of its crust,—the pure geologist cannot *id him*, but, in his turn, rather expects aid from the naturalist.

For the geologist has been taught, by his own experience, that without an investigation of the life-manifestations at successive epochs his science is fragmentary and incomplete. But the mere describing and cataloguing, the casting of them in established zoological and botanical moulds, is as likely to mislead us as to help. Such a process has misled. Half the sins of premature speculation, so often called up, like filmy ghosts, to frighten incipient geologists from the beautiful science they would follow—the charges of crudeness, hastiness, vagueness, inconsistency, and inaccuracy, brought against geology—have arisen from this mode of attempting to misconduct scientific inquiry. The geologist collected fossils without sufficient notes, and without a notion of their zoological or botanical value; he transmitted them to the zoologist or botanist, who examined them without caring to know whence they came, under what conditions they were found, or who were their associates. It was like the author mentioned by the novelist, who, when called upon for an article on Chinese metaphysics read up China on the one hand and Metaphysics on the other, and combined his heterogeneous knowledge in a wordy and well-sounding but empty disquisition. The time for such manner of work is going—has gone. The naturalist who examines fossils, if he would understand them, must study and practically acquaint himself with the principles and facts of geology. The naturalist who studies living beings, if he seek to grasp the philosophy of his science, must work among the remains of extinct creatures also. Geology must become an element of his studies. There was a time—not very long ago—there may be a few holders by it yet—when it was supposed that to be a zoologist a knowledge of comparative anatomy was superfluous; that to be a botanist no acquaintance with vegetable physiology was required. That day is gone, or expiring. The man who would now maintain such a state of things to be science is listened to with a smile, not argued with; and so will it be with all who pretend to investigate the phenomena of distribution, and the laws which determine the limits of genera and species, without a knowledge of geology.

On the principle that there is no palæontology without natural history, that there is no natural history without geology, the relations of living to extinct forms have been borne in mind in all the arrangements of this Museum, and in all the duties of those to whom the charge of the fossil collections, made by the Geological Survey, has been assigned. Moreover, in order to carry out this view to its fullest extent, the officers of the palæontological department are required to take the field when investigations demand their presence, and to study the occurrence of organic remains in the rock, as well as in the cabinet. To do this they must necessarily make themselves familiar with the practice of geological research. They must learn to appreciate the exact bearing of physical and mineral conditions on organic remains. Such, too, is clearly the method by which a knowledge of palæontology of practical value to the mining student can be acquired.

In conducting the business of this class, I look forward to the holding of field-excursions, regarding them to be quite as essential as lectures for the instruction of the student, who, to benefit by his studies, must become a practical fossilist, and learn to observe carefully fossils *in situ*, and appreciate on the spot the evidence afforded by their associations. During the progress of our winter courses this can be done effectually in the neighbourhood of London, or by means of the facilities of transport afforded by lines of railroad. I trust that before the end of this session a compact band of undaunted investigators, belted, strapped, and bag-bearing, armed with stout hammers and sharp chisels, under the veteran generalship of our director-in-chief, and officered by my mineral and geological colleagues and myself, will make the rocks shake, and yield up their treasures, for many a mile around the great metropolis.

In teaching the natural history of organic remains, we shall enforce the practice of the observation of them mainly through British examples. The principles of the study shall receive a wider range of illustration. But to learn details surely, we must acquire our knowledge through that which is most precisely known. We have abundant materials in this Museum for the minute investigation of the fossils of an area, in a geological sense, probably the most important and typical of provinces on the earth's surface. The value of the collection does not depend merely on the number of species or beauty of specimens, though in these respects we have much to boast of; it is due to the minute information preserved in our records respecting the history of individual specimens. Every fossil collected during the operations of the Geological Survey has a value far beyond any accident of fineness or rarity. It has been selected especially and precisely in elucidation of a geological fact. It is a lasting and ever-consultable memorandum of a geological observation. Its locality, its associates, the abundance or scarcity of individuals of the species at the spot and in the stratum where it was found, the mineral character of the rock itself, the condition of the specimen—whether indicative of entombment when alive, or of death before becoming imbedded, or of transport before reaching the spot where, invested with sediment, it became immortalised in stone,—all these points, essential to an accurate, to a scientific knowledge of the fossil, have been carefully noted and recorded; and the specimens incorporated with the Survey collections are worthy associates of them. We know who collected them, and how they were collected; and before they find a place in our cabinets, their history has been traced and certified.

Such materials give confidence to the student. He feels that through them he may acquire information calculated to assure him in his after-researches; he imagines for himself a safe type, a standard of comparison by which to test less perfect data. If his fate should lead him to undertake geological, mining, or exploring adventures in distant and little-known lands, he will find himself far better qualified to draw conclusions respecting the age and position of fossiliferous strata than if he had come to the inquiry with a vague general knowledge, such as he might gather from the inspection of a universal collection; for an intimate acquaintance with the fossils of all regions could not be acquired by him even during many years. He has learnt not only *how* to observe, but also *what* to observe; he has gone through that wholesome training which monographic exercises in any of the divisions of natural history invariably give. Without it, zoologists, botanists, and geologists, must be content to take place among mere declaimers and talkers about things, which, in the absence of practical knowledge, all possible reading and lecture-listening will fail to make them understand.

The collections of organic remains displayed in the galleries of this Museum are not of interest to the student only, they have a public value: they bear testimony to the correctness of our knowledge of the geological structure of the British Islands; and, where they coincide with the operations of the Geological Survey, present the minutest evidence of the age and features of the strata explored, as far as fossils can afford such evidence. And as the economic value of geological observations must ever depend on their strict accuracy —on the confidence that may be placed in them by those who would invest capital or prosecute researches on account of their faith in data officially laid before the public—such tangible proofs, open to the most severe scrutiny, as collections of organic remains made on the spot by the officers of the Survey, must have a practical importance, upon which too much stress cannot be laid.

In a country where riches are a title to high esteem and power, any branch of science that has no direct influence upon money-making is likely to be held in low estimation by the unenlightened. The meaning attached to the word *practical* in England is often nearly synonymous with *money-producing* or *money-saving*. Although I would be the last person to maintain that scientific establishments should be supported by the nation, or scientific researches respected mainly on account of such recommendation, I am not one of those who would separate science from the ordinary pursuits of men, or who would desire to see philosophers withdrawing themselves from the multitude, by keeping their thoughts unmingled with the meaner aims of the crowd. When science, provided she be mindful of her honour, and make no sacrifices of her love of truth, serves as the handmaiden of even the humblest of arts, her dignity gains in lustre, and her familiarity breeds respect. There is no department of science without some ties with the common business of life. Even palæontology may have a direct as well as an indirect influence on commercial enterprises. An example or two, out of many, may serve as an illustration.

Not long ago considerable funds were spent in a district in the west in a useless search for coal. The adventurers, ignorant of geology, had set to work in dark Silurian shales, among the oldest of stratified rocks, and far beneath our carboniferous strata. Their mineral aspect, however, resembled that of certain coal-shales with which the miners were familiar. Had they possessed even a slight acquaintance with organic remains, they would have abandoned their profitless experiment at the very commencement; for the shales in which they were working were charged with graptolites, extinct zoophytes, which do not range higher than the lowest fossiliferous group, and the presence of which indicated the true character of the strata beyond question. The fossils did not escape the notice of the miners. They collected them, and grew the more confirmed in their mistake; for, unacquainted with the differences, they mistook them for coal plants. They might have bored through the earth's centre without coming to the treasure they sought; their only chance of reaching it was by perforating quite to the antipodes.

In a second example I was myself personally concerned. Some years ago, when as yet but a student attending the geological and mineralogical lectures of Professor Jameson, I opposed by letter in a provincial journal a mistaken enterprise upon which much money was unfortunately spent. The object of it was to sink through the old red sandstone, with the hope of reaching coal, in a district where such a search was hopeless. The parties engaged were confirmed in their intentions by the advice of practical coal-miners well acquainted with the collieries of the north of England. These men argued, that since there was limestone and sandstone similar to those rocks associated with coal, and overlying it, in the districts where they had worked, therefore the strata were the same, and coal should be found. I pointed out, chiefly from the evidence of the fossils contained in the limestone overlying the sandstone, that the rocks on which they proposed to operate were only like to, but not identical with, those to which they were compared. I told them—the warning was proffered in vain—that they were throwing away their money. One of the shareholders, an intelligent man, and a reader of elementary works on geology, replied to my objections, by attempting to meet them on scientific grounds. In some old-fashioned books it used to be asserted, that shells of the genus *Cardium*—in plainer language, cockle-shells—when found fossil, are characteristic of tertiary strata. "Now," wrote my opponent, "cockles abound in the limestone in question, therefore it is tertiary, and the carboniferous strata must lie beneath." He had mistaken certain forms of *Terebratula*, shells of a very different order, for cockles; a very unfortunate mistake, for the error was persisted in, and much good gold turned into irremediable dust.

I have cited these instances because they not only shew how serious an error, leading to considerable pecuniary losses, may be committed in consequence of ignorance of science, but also are examples of the danger of inaccurate or fancied knowledge. In both these cases the fossils were noticed, but, through ignorance of these distinctions, altogether mistaken.

There is much popular palæontology abroad, as likely to mislead as to guide. The practical value of this section of natural history depends upon its certainties, and not upon its uncertainties. In the former class may be placed the determination which fossils afford of the origin of rocks, whether they be marine or estuary or fresh-water deposits; of the relative ages of sedimentary strata; of the indications they give of the climate of different epochs; of the information they contribute respecting the ancient physical geography of our globe; of the testimony they bear to the unity, harmony, and benevolence of the Divine scheme of creation,—the same during incalculably distant centuries of primeval time as now.

Under the head of uncertainties may be ranked theories of transmutation of species; of progression towards perfection; of universal diffusion of species at ancient epochs; of the retrograde development of animal and vegetable forms in time; of original perfection and subsequent degeneration; of original generalisation of specific types, and subsequent specification; of differences in the physiological habits of creatures anciently and now. All these notions are hypothetically or theoretically advocated, more or less, by men of science at the present day. All of them, it seems to me, are at best inductions from insufficient data. They may or may not be true, but at present, as we may see by a glance at the comparative extent of our knowledge of existing and extinct forms, we are not in a condition to come to a decision on the important questions they involve.

The collections of fossils displayed in the cabinets of this Museum are highly illustrative of the great truths of geology, and are arranged so as to convey instruction on the fundamental principles of the science. The fossils of each formation—in stricter language, the creatures of each epoch in the Preadamic history of the earth's formation—are grouped together, and each group is displayed in strict geological sequence, in order of superposition of strata. Whoever studies these collections carefully may gain a clear conception of the nature of the proofs afforded by natural history of the vast duration of the earth, and the series of epochs, each characterised by a distinct creation of organised beings, that have preceded the present condition of animated nature.

Although in the commencement of our educational efforts we can scarcely hope to embrace all the subjects that spring out of the arrangements of this Institution, it behoves us to look forward to the utilization in other directions than that of geological science, even of its natural history resources. There is a great blank yet unfilled in the teaching of the numerous applications which may be made of natural history to the arts. Charming as are the exquisite examples of ceramic, vitreous, and metallic manufactures collected in our Museum, we cannot but feel that the workman, however fine his natural or acquired taste may be, is unaware of the vast variety of beautiful shapes and designs that lie unused in the treasury of nature. The aiding of the manufacturer in the perfecting of his works is one of the aims we profess. The chemist can teach him how to improve his materials, or furnish him with new substances and new pigments to use in his art; the metallurgist can shew him those metallic compounds that can give the finest effect to his castings; the mineralogist and geologist can open out fresh stores of ore and earth suitable for his operations. Cannot the naturalist also come forth with friendly aid, and render some good service?

The relations of natural history with the arts are of two kinds, either illustrative or suggestive. To the first belongs the inquiry into the nature and sources of the numerous products derived from the animal and vegetable kingdoms, and applied, or capable of being applied, as direct materials for arts and manufactures. A more perfect acquaintance with old, and a discovery or indication of new, materials adapted for the exercise of human skill and workmanship may thus be attained. But the naturalist may render higher, and, at the same time, as practical services to the craftsman, by furnishing out of the endless store of beautiful objects that are rendered familiar to him by his scientific pursuits, sources of new and exquisite design,—fancies originating in the teeming brain of nature,—God-born thoughts, that become manifest in living shapes,—all consistent,—never jarring,—in every part admirably adapted to each destined purpose. Now, the laws of these adaptations and harmonies, the proportions by which the beauty of living things is maintained, the ideas by which similar forms have been grouped in nature, and, though like exceedingly, yet wondrously dissimilar,—these are among the earnest studies of every philosophical naturalist. Surely out of such studies lessons applicable to art may be derived? What is ornamental art but the isolation and embodiment in works of human skill of the beauty that is diffused through all the works of God? And that beauty lies, not merely in the bulk of objects, nor on their surface, but is as manifest in every part and atom composing them as in the combined whole. It is in itself composite; the combination, not of lesser, but of minuter beauties. To imitate,—to approach,—we must attempt a like arrangement, in order to obtain the same exquisite result. And how, except through earnest and scientific study, can we attain the knowledge that shall enable us to discover the pathway leading towards perfection?

On Coral Reefs and Islands. By JAMES D. DANA.

(Continued from page 62.)

Formation of Reefs, and Causes of their Features and Geographical Distribution.

An inquiry into the causes and origin of the features presented by coral reefs and islands, has led us to glance at the nature of coral zoophytes, and at the effects of various agents upon their development. The way has thus been prepared for considering the bearing of these facts, and of other influencing causes, on the growth of the coral plantation as a whole. While, therefore, the preceding pages treat of zoophytes as individual species, the following will relate to those results which proceed from their accumulation, and the causes which have determined the features and geographical distribution of reefs and islands.

1. *Formation of Reefs.*

Very erroneous ideas prevail respecting the appearance of a bed or area of growing corals. The submerged reef is often thought of as an extended mass of coral, alive uniformly over its upper surface, and, by this living growth, gradually enlarging upward; and such preconceived views, when ascertained to be erroneous by observation, have sometimes led to scepticism with regard to the zoophytic origin of the reef rock. Nothing is wider from the truth; and this must have been inferred from the descriptions already given. Another glance at the coral plantation should be taken by the reader, before proceeding with the explanations which follow.

Coral plantation and coral field, are more appropriate appellations than coral garden, and convey a juster impression of the surface of a growing reef. Like a spot of wild land, covered in some parts with varied shrubbery, in other parts bearing only occasional tufts of vegetation over barren plains of sand, here a clump of saplings, and there a carpet of variously-coloured flowers—such is the coral plantation. Numerous kinds of zoophytes grow scattered over the surface like vegetation upon the land: there are large areas that bear nothing, and others that are thickly overgrown. There is, however, no green sward to the landscape; sand and fragments fill up the bare intervals between the flowering tufts; or where the zoophytes are crowded, there are deep holes among the stony stems and folia.

These observations will prepare the mind for some disappointment in a first view of coral reefs. Nature does not make greenhouses, but distributes widely her beauties, and leaves it for man to gather into gardens the choicer varieties. Yet there are scenes in the coral landscape which justify the brightest colouring of the poet: where coral shrubbery and living flowers are mingled in profusion; where Astræa domes appear like the gemmed temples of the coral world, and Madrepore vases, the decorations of the groves; and as the forests and flowers of land have their birds and butterflies, so

> " —— Life in rare and beautiful forms
> Is sporting amid those bowers of stone;"

for fish of various hues, red, blue, purple, green, and other brilliant shades, keep constant play, appearing and disappearing among the branches.

These fields of growing coral spread over submarine lands, such as the shores of islands and continents, where the depth is not greater than their habits require, just as vegetation extends itself through regions that are congenial. The germ or ovule, which, when first produced, swims free, finds afterwards a point of rock or dead coral to plant itself upon, and thence springs the tree, or some other form of coral growth.

The analogy to vegetation does not stop here. It is well known that the debris of the forest, decaying leaves and stems, and animal remains, add to the soil; and that accumulations of this kind are ceaselessly in progress; that by this means, in the luxuriant swamp, deep beds of peaty earth are formed. So it is in the coral mead. Accumulations of fragments and sand from the coral zoophytes, and of shells and other relics of organic life are in constant progress: and thus a bed of coral debris is formed and compacted. There is this difference, that a large part of the vegetable material consists of elements which escape as gases in decomposition.

whereas coral is itself an enduring rock material, undergoing no change except the mechanical one of comminution. The animal portion is but a mere fraction of the whole zoophyte.

In these few hints, we have the whole theory of reef-making: not a speculative opinion, but a legitimate deduction from a few simple facts, and bearing close analogy to operations on land. The coral debris and shells fill up the intervals between the coral patches, and the cavities among the living tufts, and in this manner produce the reef-deposit, which is finally consolidated while still beneath the water.

The coral zoophyte is especially adapted for such a mode of reef accumulation. Were the nourishment drawn from below, as in most plants, the solidifying coral rock would soon destroy all life: instead of this, the tree is gradually dying below while growing above; and the accumulations cover only the dead portions. Moreover, to prevent accident, where these accumulations do not keep pace with the progress of death, organic incrustations cover the lifeless trunk, and protect it from the dissolving waters.

But on land, there is the decay of the year, and that of old age, producing vegetable debris; and storms prostrate forests. And are there corresponding effects among the groves of the sea? It has been shewn that coral plantations, from which reefs proceed, do not grow in the "calm and still" depths of the ocean. They are to be found amid the very waves, and extend but little below 100 feet, which is far within the reach of the sea's heavier commotions.* Here is an agent which is not without its effects. The enormous masses of uptorn rock found on many of the islands may give some idea of the force of the lifting wave; and there are examples on record, to be found in various treatises on Geology, of still more surprising effects.* We must, therefore, allow that some effect will be produced upon the coral groves. There will be trees prostrated by gales, as on land, fragments scattered, and fragmentary and sand accumulations commenced. Besides, masses of the heavier corals will be uptorn, and carried along over the coral plantation, which will destroy and grind down everything in their way. So many are the accidents of this kind to which zoophytes appear to be exposed, that we might believe they would often be exterminated, were they not singularly tenacious of life, and ready to sprout anew on any rock where they may find quiet long enough to give themselves again a firm attachment.

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* During the more violent gales, the bottom of the sea is said, by different authors, to be disturbed to a depth of 300, 350, or even 500 feet; and Sir H. De la Beche remarks, that when the depth is 15 fathoms, the water is very evidently discoloured by the action of the waves on the sand and mud of the bottom. In the *Comptes Rendus*, t. xii., 774, M. Siau mentions that parallel ridges are formed on the bottom by the motion of the water, which may be readily distinguished at a depth of at least 20 metres. The hollows between such ridges or zones are occupied by the heav[illegible] substances of the bottom. Similar zones were distinguished at a depth of 1[illegible]es to the north-west of the St Paul's Roads.

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* Lyell, vol. ii., p. 38–40. Speaking of the force of the waves on coasts, Lyell mentions the transportation of a block of stone, ninety feet from its bed, which was eight feet two inches, by seven feet, and five feet one inch in its dimensions, and another nine feet two inches, by six-and-a-half feet, by four feet, having been "hurried up an acclivity to a distance of 150 feet."

In an article on the subject, by Thomas Stevenson, civil engineer, of Edinburgh, published in the Transactions of the Royal Society of Edinburgh (vol. xvi., 1845), it is stated, as a deduction from 267 experiments, extending over twenty-three successive months, that the average force for Skerryvore, for five of the summer months, during the years 1843–1844, was 611 lb. per square foot; and for six of the winter months of the same year, it was 2086 lb. per square foot, or three times as great as during the summer months. During a westerly gale, at the same place, in March 1845, a pressure of 6083 lb. was registered by Mr Stevenson's dynamometer (the name of the instrument used). He mentions several remarkable instances of transported blocks. One of gneiss, containing 504 cubic feet, was carried by the waves five feet from the place where it lay, and then became wedged so as no longer to be moved. Of the manner in which it was moved, Mr Reid (as cited by Mr Stevenson) says:—"The sea, when I saw it striking the stone, would wholly immerse or bury it out of sight, and the run extended up to the grass line above it, making a perpendicular rise of from thirty-nine to forty feet above the high-water level. On the incoming waves striking the stone, we could see this monstrous mass, of upwards of forty tons weight, lean landwards, and the back-run would uplift it again with a jerk, leaving it with very little water about it, when the next incoming wave made it recline again."

Mr Stevenson states also, that the Bell Rock Lighthouse, in the German Ocean, though 112 feet in height, is literally buried in foam and spray to the very top, during ground swells, when there is no wind. On the 20th of November 1827, the spray rose to the height of 117 feet above the foundations or low-water mark; and, deducting eleven feet for the tide that day, it leaves 106 feet, which is equivalent to a pressure of *nearly three tons per square foot.*

With such facts, any incredulity respecting the power of waves should be laid aside. Moreover, it may be remarked, that the Pacific is a much wider Ocean than the Atlantic, with far heavier waves in its ordinary state.

But it should be observed, that the sea would have far less effect upon the slender forms characterising many zoophytes, among which the water finds free passage, than on the massive rock, against whose sides a large volume may drive unbroken. Moreover, much the greater part of the strength of the ocean is exerted near tide level, where it rises in breakers, which plunge against the shores. Yet, owing to the many nooks and recesses deep among the corals, the rapidly-moving waters, during the heavier swells, must produce whirling eddies of considerable force, tending to uproot or break the coral clumps. These disrupting and transporting effects will be less and less as we recede from the shores; yet all coral depths must experience them in some degree.

There is another process going on over the coral field, somewhat analogous to vegetable decay, though still very different. Zoophytes have been described as ever dying while living. The dead portions have the surface much smoothed, or deprived of the roughening points which belong to the living coral, and the cells are sometimes half obliterated, or the delicate lamellæ worn away. This may be viewed as one source of fine coral particles; and as the process is constantly going on, it is not altogether unimportant. This material is in a fit condition to enter into solution, and it cannot be doubted that the water receives lime from this source, which is afterwards yielded to the reef.

In the Alcyonia family, which includes semi-fleshy corals, and the Gorgoniæ, the lime is often scattered through the polyps in granules; and the process of death sets those calcareous grains free, which are constantly added to the coral sands. The same process has been supposed to take place in the more common reef corals, the Madrepores and Astræas, and it is possible that this may be to some extent the case. Yet it would seem, from facts observed, that after the secretion has begun within the polyp, the secretion of lime going on takes place *against* the portions already formed, and in direct union with them, and not as granules to be *afterwards cemented.*

The *mud-like* deposits about coral reefs have been attributed to the causes just mentioned, but without due consideration. There is an unfailing and abundant source of this kind of material in the self-triturating sands of the reefs acted upon by the moving waters. On the seaward side of the coral island, and on the shores of the larger lagoons, where the surface rises into waves of much magnitude, the finer portions are carried off, and the coarser sand remains alone to form the beaches. This is a well-known fact, common on all shores exposed to the waves, coral or not coral, and to this cause the sandy character is attributed. But in the smaller lagoons, where the water is only rippled by the winds, or roughened for short intervals, the trituration is of the gentlest kind possible, and, moreover, the finely pulverized material remains as part of the shores. Thus the fine material of the mud must be constantly forming on all the shores, for the sands are perpetually wearing themselves out; but the mud accumulates only in the more quiet waters, and within the lagoons and channels, where it settles, after being washed out from the beaches. This corresponds exactly with the facts; and every lake, pool, or water of our continents, illustrates the same point.*

The coral world, as we thus perceive, is planted like the land with a variety of shrubs and smaller plants, and the elements and natural decay are producing gradual accumulations of material, like those of vegetation. The history of the growing reef has, consequently, its counterpart among the ordinary occurrences of the land about us.

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* Mr Darwin, in discussing the origin of the finer calcareous mud (*Op. cit.*, p. 14), supposes that it is derived, in part, from Fishes and Holothurias; and other authors have thrown out the same suggestion. He cites as a fact, on the authority of Mr Leisk, that certain fish browse on the living zoophytes; and from Mr Allan of Forres he learned also that Holothurias subsisted on them. With regard to the facts here stated, I can make no definite assertion. Small fish swarm about the branching clumps, and when disturbed, seek shelter at once among the branches, where they are safe from pursuit: I have often witnessed this fact, and never saw reason to suppose that they clustered about the coral for any other purpose. It is an undoubted fact, however, as stated by Mr Darwin, that fragments of coral and sand may be found in the stomachs of these animals, though this is not sufficient evidence of their browsing on the coral. The conclusion deduced by him from the facts may be justly doubted. The fish and Holothurias, though numerous, are quite inadequate for the supply; and moreover we have, as explained above, an abundant source of the finest coral material without such aid. Motion of particle over particle, will necessarily wear to dust, even though the particles be diamonds; and this incessant grinding action about reefs, accounts satisfactorily for the deposits of coral mud, however great their extent.

The progress of the coral formation is like its commencement. The same causes continue with similar results, and the reader might easily supply the details from the facts already presented. The production of debris will necessarily continue to go on; a part will be swept by the waves, across the patch of reef, into the lagoon or channel beyond, while other portions lodge on its surface. But besides the small fragments, larger masses will be thrown on the reefs, by the more violent waves, and commence to raise them above the sea. The *clinker fields* of coral, by this means produced, constitute the first step in the formation of dry land. Afterwards, by further contributions of the coarse and fine coral material, the islets are completed, and raised as far out of the water as the waves can reach, that is, from six to ten feet. The ocean is thus the architect, while the coral polyps afford the material for the structure: and when all is ready, it sows the land with seed brought from distant shores, covering it with verdure and flowers.

The growth of the reefs and islands around high lands, is the same as here described for the atoll. The reef rock, in all cases, is mainly a result of accumulations of coral and shell debris. There are reefs where the corals retain the position of growth, as has been described on a former page. But with these, the debris comes in to fill up the intervening spaces or cavities, and make a compact bed for consolidation. There are other parts, especially the outer reef along the line of breakers, which are formed by the gradual growth of layer upon layer of incrusting Nullipores; but in the Pacific, such formations are of small extent.*

Among the peculiarities of coral islands, the *shore* platform appears to be one of the most singular. It will be remembered that it lies but little above low tide level, and is often 300 feet in width, with a nearly flat surface throughout.

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* Professor Agassiz has recently observed that deposits of this last kind constitute in many places the reef rock about the Florida Keys.

Though apparently so peculiar, the existence of this platform is due to the simple action of the sea, and is a necessary result of this action. Passing to New Holland, from the coral islands of the tropics, we there found the same structure exemplified along the *sandstone* shores of this semi-continent, where it is continued for scores of miles. At the basis of the sandstone cliff, in most places one or more hundred feet in height, there is a layer of sandstone rock, lying, like the shore platform of the coral island, near low tide level, and from fifty to one hundred and fifty yards in width. It is continuous with the bottom layer of the cliff; the rocks which once covered it have been removed by the sea; its outer edge is the surf line of the shore. At low tide it is mostly a naked flat of rock, while at high tide it is wholly under water, and the sea reaches the cliff. New Zealand, at the Bay of Islands, afforded us the same fact again, in an argillaceous sand rock; and there was no stratification in this case to favour the production of a horizontal surface; it was a direct result from the causes at work—the shore shelf stands about five feet above low water.

A surging wave as it comes upon a coast, gradually rears itself on the shallowing shores; finally, the waters at top, through their greater velocity, plunge with violence upon the barrier before it. The force of the ocean's surges is therefore mostly confined to their summit waters, which add weight to superior velocity, and drive violently upon whatever obstacle is presented. The lower waters of the surge advance steadily but more slowly, owing to the retarding friction of the bottom; the motion they have is directly forward, and thus they act with little mechanical advantage; moreover, they gradually swell over the shores, and receive in part the force of the *upper* waters. The wave, after breaking, sweeps up the shore till it gradually dies away. Degradation from this source is consequently most active where the upper or plunging portion of the breaker strikes.

But further, we observe that at low tide the sea is comparatively quiet; it is during the influx and efflux that the surges are heaviest. The action commences after the rise, *is strongest* from half to three-fourths tide, and then diminishes again near high tide. Moreover, the plunging part of the wave is raised considerably above the general level of the water. From those considerations, it is apparent that the line of greatest wave action must be above low water level. Let us suppose a tide of three feet, in which the action would probably be strongest when the tide had risen two feet out of the three; and let the height of the advancing surge be four feet; the wave at the time of striking, would stand with its summit three feet above high tide level; and from this height would plunge obliquely downward against the rock, or any obstacle before it. It is obvious, that under such circumstances, the greatest force would be felt, not far from the line of high tide, or between that line and three feet above it. In regions where the tide is higher than just supposed, as six feet for example, the same height of wave would give nearly the same height to the line of wave action, as compared with high tide level. Under the influence of heavier waves, such as are common during storms, the line of wave action would be at a still higher elevation, as may be readily estimated by the reader.

Besides a line of the *greatest* wave action, we may also distinguish a height where this action is entirely null; and it is evident, from facts already stated, that the point will be found somewhat above low tide level. The lower waters of the surge, instead of causing degradation, *are accumulative* in their ordinary action, when the material exposed to them is moveable; they are constantly piling up, while the upper waters are rending and preparing material to be carried off. The height at which these two operations balance one another will be the height, therefore, of the line of no degradation. As the sea at low tide is mostly quiet, and the lower of the surging waters swell on to receive the upper and parry the blow, and moreover, there is next a return current outward, we should infer that the line would be situated more or less above low tide, according to the height of the tide, and the surges accompanying it. We are not left to conjecture on this point, for the examples presented by the shores of New Holland and New Zealand, afford definite facts. Degradation has there taken place sufficient to carry off cliffs of rock of great extent; yet, below a certain level, the sea has had *little or no effect.* This height, at New Holland, is three feet above ordinary low tide, and at New Zealand, about five feet. With regard to the height varying with the tides, we observe that in the Panmotus, where the water rises but two or three feet, the platform is seldom over four to six inches above low tide, which is proportionally less than at New Holland and New Zealand, where the tide is six and eight feet. From these observations, it appears that the height of no *wave action*, as regards the degradation of a coast under ordinary seas, is situated near one-fifth tide in the Panmotus, and above half tide at New Zealand, shewing a great difference between the effect of the comparatively quiet surges of the middle Pacific, and the more violent of New Zealand. Within the Bay of Islands, where the sea has not its full force, the platform, as around the "Old Hat," is but little above low water level. The exact relation of the height of the platform to the height and force of the tides, remains to be determined more accurately by observation. While, therefore, the height of the shore platform depends on the tides and the usual strength of the waves, the breadth of it will be determined by the same causes in connection with the nature of the rock material.*

It is apparent that one single principle meets all the various cases. The rocky platform of some sea shores, the low tide sand-pit on others, and the coral-reef platform of others, require but one explanation. The material of the coral platform is piled up by the advancing surges, and cemented through the infiltrating waters. These surges, advancing towards the edge of the shelf, swell over it before breaking, and thus throw a protection about the exposed rocks; and as the tide rises, this protection is complete. They move on, sweeping over the shelf, but only clear it of sand and fragments, which they bear to the beach.

The isolated blocks in the Panmotus which stand on the platform, attached to it below, are generally most worn one or two feet above high tide level, a fact which corresponds with the statement in a preceding paragraph with regard to the height of the greatest wave action.

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* On basaltic shores it is not usual to find a shore platform, as the rock scarcely undergoes any degradation except from the most violent seas; such coasts are consequently often covered with large fragments of the basaltic rocks. But on sandstone shores, this gradual action keeps the platform of nearly uniform breadth. Moreover, any uptorn masses thrown upon it, are soon destroyed by the same action and carried off; and thus the platform is kept nearly clean of debris even to the base of the cliff.

In addition to this ordinary wave action, there are also more violent effects from storms; and these are observed alike on the Australian shores referred to, and on those of coral islands. The waters, moving through greater depths, and driving on with increased velocity up the shallowing shore, among cavities or under shelving layers, break and lift the rocks of the edge of the platform, and throw them on the reef. From the observations of Mr Stevenson, cited in a note to a preceding page, it appears that the force of the waves during the summer and winter months differs at Skerryvore more than 1200 lb. to the square foot—in the former averaging but 636 lb., and in the latter 2086 lb.; while in storms it was at times equivalent to 6083 lb. The seasons are not as unlike in the tropical part of the Pacific. Still there must be a marked difference between the ordinary seas and those during stormy weather. We have therefore no difficulty in comprehending how the ordinary wave action should build up and keep entire the shore platform, while the more agitated seas may tear up parts of the structure formed, and bear them on to the higher parts of the island. Still more violent in action are the great earthquake waves which move through in the very depths of the ocean.

These principles offer an explanation also of the general fact, that the windward reef is the highest. The ordinary seas, both on the leeward and windward sides, are sufficient for producing coral debris and building up the reef, and in this work the two sides may go on with almost equal rate of progress: consequently, we may often find no very great difference in the *width* of the leeward and windward reefs, especially as the wind for some parts of the year has a course opposite to its usual direction. But seldom, except on the side to windward, is a sufficient force brought to bear upon the edge of the platform, to detach and uplift the larger coral blocks. The distance to which the waves may roll on without becoming too much weakened for the transportation of *uptorn blocks,* will determine the outline of the forming land.

With proper data as to the force of the waves, the tides, and the soundings around, the extent of the shore platform might be made a subject of calculation.

The effect of a windward reef in diminishing the force of the sea is sometimes shewn in the influence of one island on another. A striking instance of this is presented by the northernmost of the Tarawan islands. All the islands of this group are well wooded to windward—the side fronting east, between north and south. But the north side of Tari-tari is nothing but a bare reef, through a distance of twenty miles, although the south-east reef is a continuous line of verdure. The small island of Makin, just north of Tari-tari, is the breakwater which has protected the reef referred to from the heavier seas.

Coral-island accumulations have one advantage over all other shore deposits, owing to the ready agglutination of calcareous grains, as explained in a following page. It has been stated, that coral sand-rocks are forming along the beaches, while the reef-rock is consolidating in the water. A defence of rock against encroachment is thus produced, and is in continual progress. Moreover, the structure built amid the waves will necessarily have the form and condition best fitted for withstanding their action. The little islet of an atoll is therefore more enduring than hills of harder basaltic rocks. Reefs of zoophytic growth but "mock the leaping billows," while other lands of the same height gradually yield to the assaults of the ocean. There are cases, however, of wear from the sea, owing to some change of condition in the island, or in the currents about it, in consequence of which, parts once built up are again carried off. Moreover, those devastating seas which overleap the whole land, may occasion unusual degradation for some parts. Yet these islets have within themselves the source of their own repair, and are secure from all serious injury.

The lagoons in coral islands are constantly receiving more or less debris from the reefs; and patches of growing coral within also tend to fill them up. But the effect is slow in its progress, and none but islands of small size, as before stated, *shew any* approximation to an obliteration of the lagoon.

(*To be continued.*)

On the Filaria in the Blood of the Domestic Dog.

By MM. GRUBY and O. DELAFOND.*

Messrs Schmitz, Baer, Valentin, Vogt, and Remak, had previously noted the existence of species of Filaria, Monostoma, and Distoma, and of Infusoria, inhabiting the blood of frogs, of certain fishes, and of some molluscs, but no observer had proved the presence of Nematoideæ living in the blood of animals higher in the zoological scale.

We first announced to the Academy, in the course of the year 1843, that we had discovered Entozoa of the genus Filaria living in the blood of certain domestic dogs, and circulating with the globules of that fluid in all the vessels. Since our communication to the Academy, MM. Erdl and Mayer in 1843; Hyrtl Gros, and Ecker, in 1845; Chaussat and Wedl, in 1848; and M. Guérin Méneville, in 1850; have ascertained the presence of Hematozoa in the blood of the field mouse, of the black rat, of several birds and fishes, of the lobster, of the mussel, and of the earth and silk worms. This third memoir, which we have the honour to present to the Academy, comprises the researches to which, for many years, we have devoted ourselves, on the worms living in the blood of certain domestic dogs.

We said, in our preceding communications, that this Helminth was a Filaria; and we called your attention to the circumstance that, up to that time, we had not met with this worm save in the microscopic state. Yet in studying this helminth at different ages of the life of the dog, we had proved that in the space of near two years, the microscopic filaria were slowly developed in the blood, and that then the mouth, the digestive canal, and the sexual organs appeared more distinct. And, moreover, that, in three dogs with vermiferous blood, aged from three to ten years, which we had kept several years, whose blood we had examined after death, and dissected the vessels and all the organs, we had never found other than microscopic filaria.

Although convinced of the constant existence of these worms along with the globules of the blood in all the red vessels, we had, nevertheless, been unable to account for their origin.

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* *Vide* Comptes Rendus, January 1852.

We continued our researches, and, after *two years* of laborious and patient study, we discovered in the blood of a dog with vermiferous blood, which died from the effects of a diet composed exclusively of gelatine, some large worms visible to the naked eye. These entozoa, six in number, of which four were females and two males, were lying in a large blood clot, of recent formation, which filled and dilated the right ventricle of the heart. These helminths were white, filiform, from 14 to 20 centimetres in length, and from one to one-and-a-half centimetres in diameter. We have been able to make out the zoological characters of the male and of the female, to recognise the anatomical disposition of the organs, external and internal,—to study the development of the eggs in the ovaries, and of the embryo in the oviduct, and to convince ourselves that these embryos were identical with the microscopic filaria which we had seen circulating with the blood in all the vessels of several dogs.

The blood of the animal in which we found these large worms, itself contained so great a number of microscopic filaria, that we were able to count as many as twelve or fifteen of them in one drop of blood. We observed that the large worms belonged to the genus Filaria, and to the species papillosa, but that these filaria possessed besides some distinctive characters which must make them be considered as a species still unknown. We propose to give to this Nematoidea the name *Filaria papillosa hæmatica canis domestici.* Founding on the facts we have just stated, we believe ourselves authorised in concluding, that the large filaria of the blood of the domestic dog lay the eggs of the microscopic filaria in that liquid. These young filaria, up to a certain period of their development, circulate with the blood in all the vessels. It is not until after they have acquired a diameter greater than that of the capillaries that they abide in the heart and the large blood canals.

The discovery of these adult filaria had brought us to an important point, but our researches were by no means finished. A crowd of interesting questions still remained for elucidation. The following are the results of our researches:—

1st, The number of the microscopic filaria in the blood of certain dogs may be estimated approximately from 11,000 to near 224,000. The mean number in twenty dogs was more than 52,000.

2d, The microscopic filaria, having a less diameter than the globules of the blood, circulate in the smallest capillary vessels through which the globules can pass. One drop of blood taken from the vessels, it matters not in what part of the body, nor in what season of the year, contains these little Hematozoa.

3d, The chyle and the lymph of the dogs whose blood contains microscopic filaria, even in very great number, do not contain any of these worms.

4th, The normal liquid secretions, such as the saliva, the bile, the pancreatic juice, the urine, the spermatic fluid, the serosity of the great serous membranes, as well as the fluids abnormally secreted, do not contain any of these minute animals.

5th, Twenty-eight dogs with vermiferous blood, of different kinds and ages, kept, some during several months, others during more than five years, animals which had approximately from 11,000 to near 224,000 microscopic filaria in their blood, have been dissected in the course of the winter, the spring, the summer, and the autumn, with the greatest care, without a single filaria, invisible or visible to the naked eye, having been perceived in the different tissues. We think, then, we are able to affirm, that the filaria of the dog, whether microscopic or of from 14 to 20 centimetres in length, and near 1 millimetre in diameter, or of the size of a thick thread, lives exclusively in the blood during all seasons of the year, draws nourishment from that fluid, and never abandons it.

6th, The frequency and the rarity of dogs having vermiferous blood, and of those without it, calculated from 480 dogs, the blood of which has been examined, is, in the mean proportion, one dog with vermiferous blood to twenty or twenty-five without it.

7th, Vermiferous blood occurs more frequently in old and adult dogs than in young.

8th, These worms appear in the blood of dogs without distinction of kind or of sex, and whatever be the state of leanness, of fatness, of health and of disease, of these animals.

9*th*, The microscopic filaria, even when present in the approximate number of near 224,000, do not alter the instinctive faculties of the dogs, and do not at all weaken the muscular energy of these animals.

10*th*, The vermiferous blood of the dogs presents no very notable modifications in its physical characters, and in the proportionate weight of its organic and inorganic principles.

11*th*, The microscopic hematozoa transfused with from 150 to 300 grammes of a *liqueur globuleuse defibrinæ* into the vessels of nine dogs, whose blood contained no worms, disappeared from their blood in from the eighth to the fortieth day. The dogs were killed, and the filaria were neither found in the fluid secretions, nor in the tissues, nor in the different cavities.

12*th*, In two dogs, differing in kind and age, having no filaria in their blood, into whose vessels from 200 to 800 grammes of vermiferous defibrinised blood were ejected, the filaria have continued to live in the blood during more than three years, or up to their natural death. When opened and dissected these dogs have not presented any filaria save in their blood.

13*th*, The microscopic hematozoa of the blood of the dog transfused with the *liqueur globuleuse defibrinæ* into the vessels of two rabbits, have continued to live in the blood of one of them during eighty-nine days, after which time the filaria disappeared from the blood. At the autopsy of this rabbit the filaria were not found again in the tissues.

14*th*, The microscopic filaria transfused with the defibrinised liquor which we have mentioned into the blood of six adult frogs, two of which already had filaria in their blood, continued to live in the vital fluid of these animals during eight days, or during the time the globules of the dog's blood appeared unchanged among the globules of the frog's blood. On the ninth and tenth day, the globules of the dog's blood being altered, the microscopic filaria injected with it disappeared, and the eight frogs died of a scorbutic disease. These transfusions then demonstrate that the microscopic *filarious* blood cannot continue to live, either in the blood of the dog, or in that of other animals, save so long as that fluid possesses a constitution proper, and still unknown, to the maintenance of the life of these hematozoa.

15*th*, The filaria invisible to the naked eye injected alive, along with the blood which transports them along the vessels into the serous cavities, and the cellular tissue of healthy dogs, were unable to remain alive in these two new domiciles.

16*th*, A dog with vermiferous blood, with a female with blood not vermiferous, produces offspring, of which those belonging to the race of the father have vermiferous blood, while the others, pertaining to the race of the mother, have not.

17*th*, A vermiferous-blooded female dog, produced with a male dog without vermiferous blood, brings forth pups, of which those taking after the race of the mother have worms in their blood, while those resembling the father in race have none.

18*th*, A vermiferous-blooded female dog, with a male dog equally so, has pups with worms in their blood, whether these pups pertain to the race of the father or of the mother.

19*th*, The filaria in the blood of the pups have not been discovered before they have reached the age of from five to six months. The worms have continued to live in the blood of these animals, which have now reached the age of four or five years.

20*th*, Nineteen dogs, of which each had approximately from 11,000 to about 224,000 microscopic filaria in its blood, and also a dog having also in its blood six adult filaria, from fourteen to twenty centimetres in length, have never been seized with any special disease. Three dogs, however, having, approximately, the first 17,000, the second 25,000, and the third 112,000 microscopic filaria in the vital fluid, have been struck with epileptic-like attacks. Two of these animals died of the attacks; in the third the attacks have ceased. The health of this last dog has been perfect for more than a year, although the same number of worms always exists in the blood. Very numerous researches will yet be made on this interesting subject.*

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* The author announces a new memoir on a strongylus which lives in the mesenteric arteries of the horse, and on the hematozoas, which live in the crow, the frog, and in many species of fish, and in the lumbricus terrestris or earthworm.

Description of a Self-Acting Apparatus for preventing Water-Pipes Bursting during Frost. By Mr ALEXANDER MACPHERSON, F.R.S.S.A., of Leith. Communicated by the Author. With a Plate.

It is unnecessary for me to point to the highly-injurious consequences which often result from the bursting of water-pipes with frost; or to demonstrate the great necessity there exists for some proper and efficient remedy. With the exception, perhaps, of a serious fire, there is no agent more destructive in its effects upon property than an overflow of water. It is true that such an occurrence is frequently occasioned by the defective nature of the plumber-work; but there can be no doubt whatever, that the most prolific source of this kind of damage is due to the bursting of water-pipes with frost; and that is an event, it would seem, which the most skilfully-executed plumber-work can neither prevent nor resist.

The temperature in this country is rarely so low as to exhibit the consequences of a severe and protracted frost; and the cases of burst water-pipes have, therefore, been comparatively few. Since the winter of 1838–9, we have had no severe frost of any duration; but in that year, and others of equal severity, the water-pipes were burst all over the country, and this occasioned damage to a very large amount. While this country, however, from its temperate climate, is, in a great measure, exempted from these effects of frost, it is different in countries where a colder temperature predominates. In the northern section of the United States and Canada, this freezing of the pipes assumes a much more formidable aspect. Many of the houses are warmed with furnaces placed in the cellars or halls; and I believe one of the chief objects of this expensive precaution, is that of preserving the water-pipes from freezing.

There have been various attempts made to prevent the action of frost on water-pipes. Exterior protections of such non-conducting materials as charcoal, ropeyarn, straw, &c., have been applied to the exposed parts of the pipes, with the view of preserving the temperature. These, it is obvious, can afford but very slight protection in the event of an intense frost. It has been very generally recommended, also, as a useful precaution, to circulate the water through the pipes, by means of partially opening the cock at the sink. This, when it can be adopted with safety, is, to a certain extent, beneficial in preserving the supply-pipes from bursting; but it has been found extremely disadvantageous in freezing, and consequently obstructing, the soil-pipes and drains. From this cause, it is very often—as in New York—prevented by the municipal authorities. The attempt, which I have frequently seen made, to resist the frost by means of strong pipes, is very absurd. No strength of pipes of any material can withstand the expansive force of water while freez-

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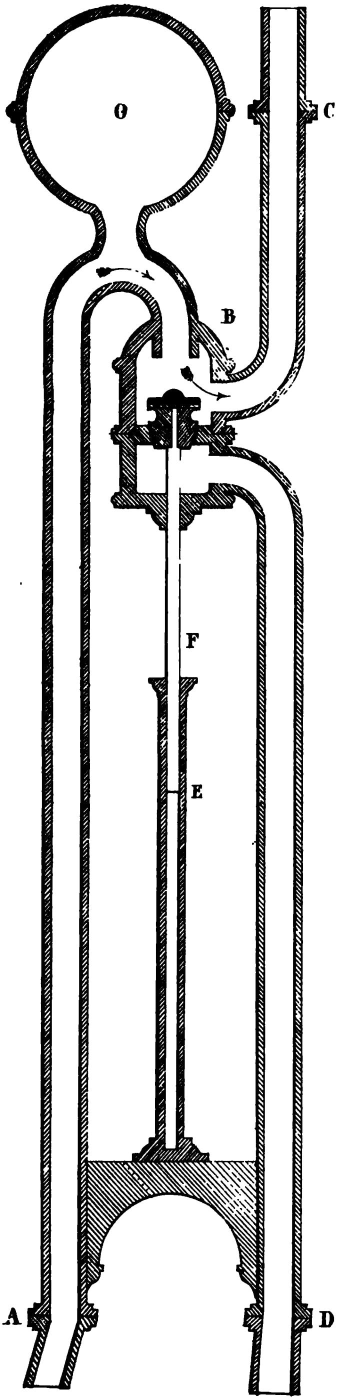
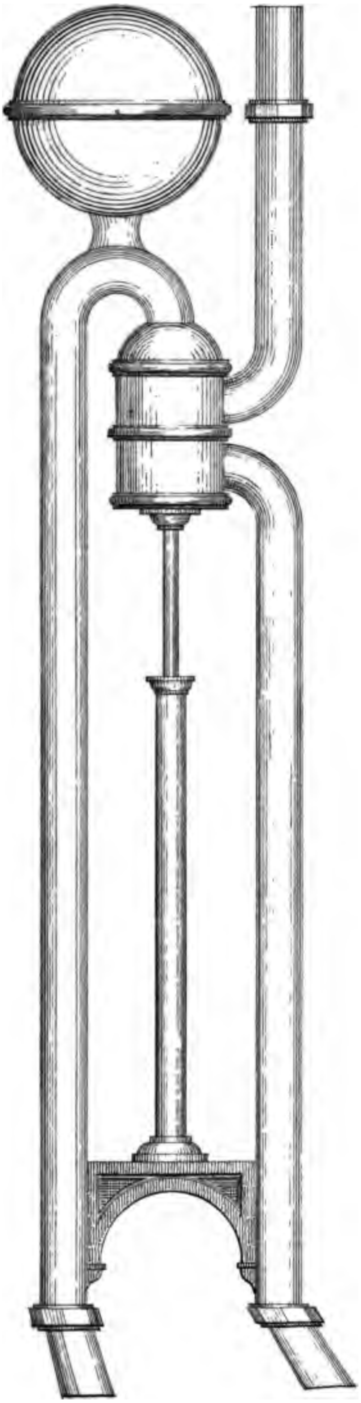
RSON'S APPARATUS FOR PREVENTING WATER PIPES FROM BURSTING DURING





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ing. I may add to this, that the practice of building up water-pipes in the centre of a wall, with the view of preserving them from bursting, is dangerous in the extreme. The ill effects of the frost on the pipes is often imperceptible at the time. The expansion sustained by the pipe may not be sufficiently great to burst it; but in that case it produces a regular enlargement of the pipe, which part necessarily becomes the weakest; and it accordingly yields sooner or later to the mere pressure of the water. Cases of burst pipes in summer have thus not unfrequently to be attributed to the frost of the previous winter.

The only really practicable and unfailing means of preserving water-pipes from bursting with frost, is to adopt the simple precaution of *keeping them empty*. This has been well ascertained to be the only security in every country where precautions are adopted. The best of those in use at present, consists in attaching a stop-cock to the lowest part of the pipes, and another immediately above it. By the one, the water is shut off when a low temperature approaches, and by the other, the pipes are emptied of the water they contain. To render these precautions of any avail however, the utmost watchfulness is necessary, and even where the cocks exist, they are rarely used in time. Besides, a severe frost will frequently occur in course of a single night, and in that case the opportunity of shutting off the water is lost. The same objection applies to the mode of heating by fires, of circulating the water, and to all other precautions of a similar kind.

Reasoning on this, I have conceived the possibility of employing some self-acting apparatus, which, on the approach of a low degree of temperature, would of itself shut off the water and empty the pipes; or, in other words, of having a machine so constructed and regulated, that it would shut a cock before the freezing-point of water, and open it again, when the temperature assumed its normal state.

I first thought of applying a machine on the principle of the thermometer. If, in place of the small bulbous glass of an ordinary thermometer, I took a vessel of much larger dimensions, and in place of being sealed at the top, it was closed by means of a small sliding piston on the surface of the mercury;—if it were possible to adjust this, so as to elevate the piston at a temperature of 60°, it is evident that a decrease of the temperature to the freezing-point would produce a diminution of bulk in the mercury, and a corresponding descent of the piston. A stop-cock on the supply-pipe, attached to the piston-rod, might thus be made to stand open at all ordinary temperatures, and to shut precisely at the freezing point.

Such an apparatus, however, would be subject to a few serious and insurmountable objections. In the first place, it would require some intricate mechanical arrangement, to prevent it diminishing the supply of water at low temperatures, although still above the freezing-point. In the next place, its whole available power in shutting the cock would necessarily be small, since it could only be derived from the atmospherical pressure on the surface of a very small piston; and, lastly, it would, according to the determination of Dulong and Pétit, require about 400 cubic inches of mercury to produce one single cubic inch of vacuum in its depression between those two degrees of temperature. In short, it would not answer the purpose.

The next idea was kindly suggested to me by Sir David Brewster. It was to employ the expansion of metallic rods, on the principle of the pyrometer, to effect the same purpose; and something analogous to the original pyrometer of Muschenbrock would probably be the best adaptation. A bar of zinc, or any other expansive metal, of convenient length, may have its expansion or contraction increased to any extent, by a series of compound levers; and this might be applied as the motive power in a manner precisely similar to that described. But the mechanical difficulty of regulating the action of the pyrometer between two specific degrees of temperature again interposes; otherwise, I have no doubt but that a properly-constructed apparatus of this kind might be the most unfailing means of action I could adopt. It has these advantages over the mercury, that its power is irresistibly great, its cost would be trifling, and it would be of much easier application.

Finding these instruments to be practically inapplicable, I was driven to think of something more resembling the sudden expansion of water when freezing. It is obvious that this remarkable property of water is unlike the regular expansion of metals. What was necessary, I then thought, must be some liquid that will solidify a degree or two higher than water, and of its expansion being applied to shut off the water. Glacial acetic acid assumes the state of a solid at a temperature so high as 45°, and sulphuric acid of the density of 1·78 does the same at 46° Fahr. I was proceeding to experiment upon these, or similar bodies, when it occurred to me that of all the applications of this kind the best might be found to exist in the *expansive force of water itself* when freezing.

Water, according to the experiments of Boyle and Dalton, increases in bulk about one-ninth in its transition from the fluid to the solid state. This expansion occurs with an irresistible degree of force. The Florentine academicians burst a hollow brass vessel with a cavity of only 1 inch in diameter, by freezing the water it contained. The force produced was equal to 27,000 lb. Major Williams, in his experiments at Quebec, in 1784–5, besides bursting bombshells, projected an iron plug, 2⅝ lb. in weight, from one of the shells, to a distance of 415 feet by the expansive force of the water it contained when freezing. These facts afford sufficient grounds for establishing the most important points of the desired motive power; those, namely, of the amount of expansion the water sustains, and the prodigious force with which that is accompanied. I calculated, that I would require in a vessel, such as I have described, 27 cubic inches of water, which would produce 3 inches of expansion, to act effectively on a stop-cock.

I therefore procured a globular glass vessel of these dimensions, accurately fitted with a cylinder and piston, and filled it with water. On exposing it to freeze, however, the water expanded equally on all sides of the vessel and burst it, instead of elevating the piston. A thin sheet brass vessel I employed for the same purpose succeeded no better. But, after a number of similar experiments, on vessels of different shapes, which I need not detail, I ultimately found that a true and accurately bored cylinder was the only vessel in which water could be frozen under pressure. This it was of great importance to ascertain; for had it occurred that ice expanded uniformly in a lateral direction it is plain that no vessel of moderate strength could have resisted the pressure. From these experiments I found that in a simple tube of any convenient dimension, fitted with a piston, it would be, without bursting, elevated by the freezing of the water it contained, and with a force far beyond what was absolutely necessary. This could be applied to shut a cock, or operate in any other manner found to be most appropriate. Such is the principle of the apparatus represented.

The only apparent objection that presented itself next, was, that the water contained in the pipes being subjected to the same degree of cold as that portion confined in the small tube, would freeze as soon, or at all events so nearly at the same time that there would not be space intervening of sufficient duration to allow of the water being shut off. This objection, however, is easily disposed of by the application of a tube possessed of superior powers of conducting heat to that of the lead pipes. Copper at once suggests itself as the most appropriate, and for two reasons: 1*st*, Copper is to lead, as a conductor of heat, as 18 to 89, or, as nearly as possible, 5 to 1; and, 2*d*, Its tenacity or cohesive power is exactly ten times that of lead. These, it will be seen, are valuable properties for the purpose, since it not only guarantees a quicker conduction of heat, or, in other words, a quicker freezing of the water it contained, but a power of resisting ten times the pressure. But there is no occasion to employ a copper tube of the same dimensions as the lead pipe. One of half, or even a fourth of the size, I have found to answer quite as well. This, again, gives a still greater advantage, since the conduction of heat holds a direct ratio to the mass of the body. In short, it is very apparent that a properly-constructed copper tube, containing a small portion of water, will be the first to freeze, and so shut off the water.

The practical application deducible from these principles, consists of a very simple apparatus. A copper tube of any convenient dimensions fitted with a piston filled with water, and firmly attached to the lead pipe, would, from its superior conducting power, be the first to freeze, and by the vertical expansion of the ice to elevate a piston and shut a stop-cock, while the water in the lead pipes was still fluid. On similar principles it would be the first to become liquid on a return of temperature. But in that case it is not so certain that the piston would descend to its original position and open the cock. Indeed, unless the combined friction of the piston and cock was very small it would not. Besides, it being a primary object of the plan to empty the pipes at the moment of shutting off the water, it would be necessary in that case to employ two cocks—one for each purpose.

To obviate this I have, therefore, thought it preferable to employ a double-action valve of the description indicated in the diagram, both as regards the relative simplicity of action in a valve to that of a stop-cock, and, what is of greater importance, with the view of effecting, at the same time, the shutting off of the water and the emptying of the pipes.

Explanation of the Plate (III.)—Fig. 1 is a section; fig. 2, an elevation of the apparatus about one-fourth of full size. A represents the junction of the ingress supply-pipe, which performs a curve into the top of the double-action valve B. C is the supply-pipe continued on its ascent to the cistern. D is the waste-pipe through which the pipes are emptied. E is the small copper tube containing a measured quantity of water; it is supported by a small bracket attached to the pipes. F is the piston accurately fitting into the copper tube, and acting in direct conjunction with the valve in B. O is an air-vessel. Now, if frost act on the small copper tube, the water it contains is the first to freeze, expand, and elevate the piston, which in its turn pushes up the valve from its present seat, and shuts it with great force against the projected extremity of the ingress supply-pipe. A passage is thus opened between the ascending supply-pipe C and the waste-pipe D, through which the whole water in the pipes immediately escapes. By this means the water is shut off, and the pipes emptied at the same time. By observing that the valve shuts *against* the pressure of the water, it is evident that so soon as the water again becomes fluid, it must exert that whole pressure on the valve before it can escape, and it thus constitutes the external pressure, if any were required, to depress the piston when the temperature returns to its normal state.

This construction of valve overcomes the only remaining difficulty to the effective working of the apparatus. It should be attached to the supply-pipe at the very lowest part of it. The place where the pipe enters the house—often that of the cellar, area, or other low, exposed situation—is the best. The water-pipes should possess a downward inclination to this point—as, indeed, is generally the case—for the purpose of being completely emptied.

Mr Charles Baldwin, civil engineer, of Boston, United States, to whom I am indebted for much valuable information on this subject, suggests that an instrument of this kind might with advantage be employed to indicate the sudden approach of frost. Other applications of a similar nature may very likely be made. Meantime, I rest content with pointing out the existence of a principle which is

calculated to supply a desideratum long and universally acknowledged, and which may be described, in a word, as the simple application of the expansive force of *one* body of water, while freezing, to counteract the destructive consequences which are the ordinary characteristics of another.

Climate and Mortality of Glasgow, 1851. By ROBERT DUNDAS THOMSON, F.R.S.E., *Lecturer on Chemistry in the University of Glasgow.*

	WEIGHT OF AIR.				TEMPERATURE OF AIR.									
	Barometer corrected and reduced to 32 deg.	Pressure of Dry Air at Level of Sea.	Elastic Force of Vapour, in inches.	Vapour in a cubic foot of Air, in grains.	Dry Bulb Therm.	Wet Bulb Therm.	Mean max. Therm.	Mean min. Therm.	Mean max. and min. Therm.	Mean Tem. adopted.	Mean Tem. Dew Point.	Rain in Inches.	Days of Rain fall.	Prevailing Winds.
January,...	29·402	29·317	·235	2·78	42·4	41·0	45·3	36·5	40·7	41·5	38·	6·68	25	SW.; SE.
February,..	29·771	29·673	·248	2·88	41·5	39·9	45·8	35·9	40·4	40·9	38·2	3·05	13	SW.; W.
March,......	29·445	29·353	·242	2·82	41·9	39·9	47·9	36·	40·9	41·3	37·4	3·76	19	W.; SW.
April,......	29·732	29·644	·238	2·75	44·5	41·	52·4	38·8	44·1	44·3	37·	1·70	14	EY.; WY.
May,........	29·879	29·753	·276	3·16	50·6	45·9	58·9	43·7	49·6	50·1	38·	·43	10	N.; W.
June,.......	29·754	29·565	·339	3·85	54·	50·6	64·	48·2	54·3	54·1	47·2	2·66	16	W.; WSW.
July,........	29·650	29·419	·381	4·32	56·6	53·1	65·1	51·5	56·4	56·5	49·8	2·64	14	W.; NW.
August,....	29·815	29·576	·389	4·40	56·8	53·5	64·9	52·1	56·8	56·8	49·8	4·15	19	ENE.; SW.
September,	30·041	...	...	...	52·5	...	60·6	48·6	53·3	52·9	...	·75	7	WNW.
October,...	29·584	29·4	·304	3·48	50·6	47·3	55·2	46·1	49·6	50·1	43·9	2·89	19	E.; W.; SW.
November,	29·821	29·760	·211	2·47	38·8	36·7	42·2	34·9	38·1	38·4	33·5	1·10	12	W.; SW.; SE.
December,.	30·016	29·906	·260	3·02	43·4	41·6	45·6	38·5	42·	42·7	39·6	1·43	12	SW.; SE.
Means at Sea-Level.	29·742 29·892	29·581	·284	3·26	47·8	44·7	53·9	42·5	47·1	47·4	41·1	31·24	180	W.; SW.; SE.

The mean height of the barometer, corrected, for the year, was 29·742 inches, and reduced to the level of the sea, 29·892 inches; this very nearly approaches the usually-assumed barometric pressure at the sea-level, or 29·92 inches, the difference being only $\frac{28}{1000}$ in deficiency as respects the year. The pressure of dry air at the level of the sea, would be 29·581 inches. The pressure of vapour in the air during eleven months, was ·284 inch, and the vapour in a cubic foot of air 3·26 grains. The total fall of rain was 31·24 inches; the mean of five preceding years being 34·04, and of six years, including the present, 33·6 inches. The number of days on which rain fell was 180, giving an average of nearly 3½ days per week; the greatest number of rainy days being in January, and the least in September. The greatest height of the barometer during the year was 30·503 inches, on the 28th December, or at the level of the sea it would have stood at 30·653 inches. It was remarkable that at this period, when the barometer was considerably above 30 inches, the atmosphere was generally obscured by thick fogs and by frequent drizzle, with the wind from the S. and SE. The lowest depression of the barometer was 28·736, on the 14th July, with a S. wind, accompanied with a fall of rain (·61) upwards of half-an-inch in depth in twenty-four hours. The range of the barometer has therefore been 1·897 inches.

The distribution of the temperature of the year has been somewhat irregular. The month of January was remarkably mild, the mean heat being 41°·5 or about 7° above that of the year 1850 (34°·3); and notwithstanding the wetness of the season, the first two months of the year were not unfavourable to health. The mean temperature of the first half of the year was 45°·3, of the second half, 49°·5, and the mean of the whole year, 47°·4—a number considerably higher than could be anticipated from the latitude. It remains to be ascertained, by future observations, whether the excess of temperature over calculation is dependent on local causes. The mean temperature to the west of the city, during the year 1850, was found by Mr James King, at 9 A.M., 47°·6, and at 9 P.M., 47°·7; and by applying the Greenwich corrections, these numbers become a mean of 48°, affording a close approximation to the results of the present year. The instruments were compared with the Greenwich standard.

The highest temperature attained during the summer was 82°·4, on the 30th June, and during the two preceding days the maximum thermometer reached 80°·6 and 81°·1,—a rare circumstance in this latitude. The highest heat at Greenwich Observatory, at the same period, was 87°, with a westerly wind. The lowest temperature of the year was 25°·9, on the 3d December, making a difference in the extremes for the year of 56°·5. The connection of the temperature with the mortality, in the different months, will be best observed by constructing a table on the following plan:—

Mortality and Temperature in Different Months in 1851.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean Temperature,	41°·5	40°·9	41°·3	44°·3	60°·1	54°·1	56°·5	56°·8	52°·9	50°·1	38°·4	42°·7
Mortality at all ages,	774	814	1046	886	877	772	784	943	845	887	906	1124
Above 60 years,......	...	...	...	104	109	77	89	97	97	88	118	180
Zymotic,...............	...	...	...	298	312	275	300	413	350	384	379	442
Consumption,.........	...	...	...	161	156	154	154	166	146	131	153	207
Diseases of Lungs,...	...	...	...	64	72	54	53	50	50	59	93	153

The effect of cold on the total mortality is sufficiently obvious in November and December, and particularly on the aged and consumptive subjects. There can be less hesitation in tracing the increased deaths, in some measure, to the depression of temperature, as no epidemic prevailed peculiarly in these months. The fall of the temperature from 45° to 28°, destroys, in London, from 300 to 500 lives. Hence we can readily understand how it may have happened, that a considerable portion of the 237 cases of excess of mortality in December over October, may have been due to the operation of this depressing influence during the cold month of November. The effect of temperature may probably appear more striking from a comparison of the various quarters of the year in a population of 360,138—

	1st Quarter. Jan. to March.	2d Quar. Apr. to June.	3d Quar. July to Sept.	4th Quar. Oct. to Dec.
Mean temperature, ...	41°·2	49°·5	55°·4	43°·7
Total mortality, ...	2634	2535	2572	2917
Above 60, ...	359	290	283	386
Consumption,..........	504	471	466	491
Diseases of the Lungs, ...		190	153	305
Zymotic, ...	751	885	1063	1025

The total mortality during the winter quarters of the year amounts, according to this table, to 5551, while that of the two milder quarters is 5107, shewing a difference in favour of the warmer portion of the year of 444—the total mortality during the year being 10,746. That this mortality was not greater during the last quarter, when the temperature remained protractedly depressed, was undoubtedly due, in some measure, to the improved condition of the poorer classes in regard to food—that most natural and powerful bulwark against the attacks of disease. Notwithstanding, however, the circumstance that it is possible to account for the excess of mortality in one portion of the present year over another by natural causes, there is an excess of deaths in this city over most other towns, for which some other origin must be sought. The forbidding aspect of a large portion of the dwellings in the older parts of the town, engendering, as they do, an absence of due self-respect, followed by low and debasing habits in their inhabitants, is scarcely surpassed, in regard to extent, in any other British city. Unfortunately, the application of proper sanatory measures, by the formation of new, well-ventilated streets and houses, instead of the condensed habitations at present existing, has been confined to the great Metropolis, and will be employed as another argument in favour of centralisation, unless our local authorities are speedily prepared to devise and apply the adequate remedy. Another desideratum among those classes most liable to disease, is a plentiful supply of the purest water which can be obtained for domestic use, free from sewerage: the connection between impurity of water and mortality, having been well illustrated in the condition of London. Again, it becomes a question of import to health, if the noble Clyde, with its sewer-like waters and impure exhalations, be not equally conveying, in its present state of pollution, wealth and malady to a teeming city.

And lastly, the fearful mortality from smallpox and other endemics, urgently demands that the Scottish population should be placed on an equality with that of England, by an extension to our kingdom of the Vaccination Act, as well as of the Registration Act, which, if committed to the excellent administration of the Registrar-General of England, could be brought into operation, with the machinery at present in existence, with but a trifling addition to the expense of the country. Scotland would thus be removed from the unenviable position of being classed with Spain, Greece, Hungary, Turkey, and Ireland, as the only parts of the civilised States in Europe where authentic official registers are not kept.

NOTE.—The blanks in the preceding Tables are due to the circumstance that the new form of Mortality Bill was introduced only in April.

On Fossil Footprints. By ROBERT HARKNESS, Esq. Communicated by the Author.

Since the commencement of the present century science has made such rapid advancement that it in a great measure possesses a new and a different character. Some of its branches have so far influenced the progress of society that our present position results almost entirely from their application to the common businesses of life; and others may be said to have had their origin since the beginning of the nineteenth century. Amongst these there is none which has made more gigantic strides than geology, which seems to have burst from its swaddling bands, and hurried forward in its progress until it has become of Herculean proportions. This rapid progress which geology has made is in a measure owing to the circumstance, that this science consists in the application of facts, which other branches of science have furnished us with, to the form, structure, and contents of the planet which we inhabit. In the application of these several facts it became necessary, that, in order to any great progress being made, there should be subdivisions in geology as to lead to the application of two distinct sets of facts; one derived from what, in a restricted sense, has been termed physical science, and the other, information which natural history has given to us. To the former we are indebted for a knowlege of the conditions which have caused the different mineral deposits, and also the mode in which these are arranged, as well as other circumstances connected with their occurrence; and to the latter we owe what information we possess concerning the various races of animals which have at different periods been occupants of our earth, and which mark epochs of existences, and indicate the commencement and termination of the several geological formations. A knowledge of natural history is required before any advancement can be made in ascertaining the forms and structure of the multitudes of species which existed anterior to the present order of things; and as these ancient types of organic beings are devoid, to a great extent, of such characters as are now used in discriminating existing species, it became necessary that other and more permanent characters should be adopted, by which to trace out the affinities of extinct forms; and, consequently, we have that branch of natural history called Palæontology devoted to the examination of the characters and nature of the fossil remains which are obtained from the stratified crust of the earth. The remains of extinct races of animals are found in different states of preservation. Of the lower tribes of organic beings, such as zoophytes and shells, the structure is such as to furnish us, even in a fossil state, with many distinct characteristics of their original nature. Even the whole tribe of invertebrate animals have their external forms commonly so well preserved as to afford sufficient evidence of their relationship to existing types. The case is different with vertebrate forms, more particularly with such as are inhabitants of the land; for these, when we have any traces of them, from the rocks which generally furnish organic remains, are in such a state as to afford commonly only a fragment of a bone or a tooth, and yet from such fragments the palæontologist is able to fashion the original animal of which these formed one part, to place it in its natural habitat, to tell us whether it browsed on a luxuriant vegetation, or fed upon the herbivora which were its companions on the earth; whether, like the lion, it consumed its food in its lair, or, like the hyena, dragged it to some dusky cave, there to grind the bones of its victim at its leisure.

The existence of former races of animals does not depend solely upon the remains which their structure has left in the form of their bones, teeth, or other solid parts. We have sufficient evidence to shew, that forms, of which we have no particle left, have at various times been inhabitants of portions of our earth, leaving no other traces of their former existence save their footprints on the soil over which they traversed.

The description of these footprints, and the inferences which have been drawn from them, has given rise to a branch of palæontology called Ichnology, and to this branch we are indebted for many important additions to our geological knowledge. The Indian hunter, as he pursues that vocation to which he owes his existence, acquires information concerning the various kind of animals which are likely to become his spoil, from the impress which they have made during their progress from one place to another; and the ichnologist, by examining the different tracks which he finds on the several beds of sandstone, arrives at a knowledge of the animals which have formed these tracks, and also infers from them what were the circumstances and conditions required by these animals when they were tenants of the sandy shore, which at early periods margined the tremulous sea.

It is now about twenty-six years since Dr Duncan of Ruthwell first brought fossil footprints under the notice of geologists. These, when first discovered, were so unique, that Dr Buckland, to whom the subject was first intimated, was disposed to consider these footmarks as either fossil shells partially decomposed, or clay concretions. After inspecting casts forwarded him by Dr Duncan, he arrived at the conclusion that these impressions were veritable footprints left by animals which existed at the epoch when the red sandstone of Dumfriesshire was being deposited; this being the formation in which these footsteps are found. After the discovery of impressions in the sandstone of Corncockle Muir, Dumfriesshire, the attention of geologists became directed to this subject; and in a short while other districts were found to afford fossil tracks. Amongst these the new red sandstone of Hildburghausen, in Saxony, furnished specimens of Batrachian forms; similar tracks were also obtained at Stourton quarry, on the south side of the Mersey, opposite Liverpool, and at Lynne also, in Cheshire. Afterwards the same county afforded this form of step, in conjunction with the impressions of Saurians and Tortoises, at Weston Point. Warwickshire and Staffordshire also were found to contain fossil footprints in their new red sandstone. A deposit of a similar age, although of a somewhat different nature, in America, was met with, having its beds impressed with the footprints of birds as well as reptiles. For a considerable time the new red sandstone was regarded as the only formation from which these impressions were obtained, but they are now procured from the lower portion of the coal-measures in America; and in this country the Devonian sandstone at Elgin shews fossil footsteps, and recently even the Potsdam sandstone, which appears to occupy a position equivalent to the Llandeilo flags, the base of the Silurian, has, in Canada, made us acquainted with the existence of reptile footprints at a period which is about the earliest from which we possess evidence of the existence of organised beings. With the exception of the impressions caused by birds found in America, the whole of the footprints are of such a nature as to indicate a relation to reptiles, and amongst these we have representations of Chelonia, Sauria, and Batrachia, the three forms of reptile life, the only one wanting being Ophidiæ, which, from its structure, could not leave any traces of its former existence in the form of footsteps. With respect to the tracks which occur in the Potsdam sandstone, these shew their affinity to the steps of the Emydian family of Chelonia; and Professor Owen, from his examination of them, refers them to this form, both owing to the smaller size of the anterior extremities, and also from their legs appearing to have been of shorter length than those of land-tortoises. The fact of this animal having in some of the steps left traces of reticulation, and a groove which runs intermediate to the footprints of each side, leads to the conclusion that this chelonia was furnished with a projecting keel or plastron. Concerning the impressions found in the Devonian at Elgin, these seem to have been caused both by lizards and chelonia; and the occurrence of the Telerpeton Elginensis, a Lacertian form, which has left a portion of its structure in the sandstone of this locality, places us in possession of the oldest remains, except footprints, which have yet been discovered of vertebrata. The impressions which occur in the carboniferous rocks have, in general, a Batrachian character. In the coal-measures of Bavaria there have been obtained skeletons of reptiles, and some of these, according to Herman Von Meyer, "were provided with hands and feet, terminating in distinct toes; but these limbs were weak, serving only for swimming or creeping." This anatomist shews that these reptiles have some analogy to the Proteus anguinus, a reptile at the present time inhabiting subterranean lakes. It is, however, in the trias, the base of the secondary division of the geological formations, that we have the most abundant evidence of the former existence of reptile life, as left by their footprints. In this formation they occur in the greatest plenty in the Variegated sandstone (or *Bunter sandstein*), which forms the lowest portion of the trias.*

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* We prefer the name Variegated Sandstone to the German one, Bunter *sandstein.*—EDIT.

Whether their great abundance here be owing to this deposit being of a nature more capable of receiving and retaining impressions, or to reptilian life prevailing to a greater extent during this period, or to the sandy nature of this deposit forming a suitable habitat, is a question which yet remains to be answered. In this formation, however, many and various forms of reptiles have left their tracks, and these tracks are in a much better state of preservation than those which the other formations afford.

Variegated sandstone, from whence the great bulk of the ichnolite markings are obtained, generally affords them in two conditions; one in which they are seen on the upper surface of the sandstone strata, and consisting of depressed markings, and the other when they occur in the *under side* of the stony layers, in which case the footprints are in relief, and form natural casts of impressions, commonly from a clayey deposit, which is usually too thin to be removed perfect from its original bed. The character of these impressions, so far as their perfection is concerned, depends in great measure upon the nature of the substance receiving the footstep, as well as upon the action of the water transporting the sandy matter which covers up and overlies the strata containing the impressions. When the animal has traversed a dry, sandy shore, we have the footprints distinct, so far as order and succession go, but, owing to the yielding sand trickling into the impressions as soon as the foot which caused them had been withdrawn, these tracks rarely present that sharp and definite outline which would enable a satisfactory conclusion to be drawn from them, concerning the form and nature of the animal to which they owe their origin. If the nature of the substance over which the animal walked was originally in a state approaching to quicksand, from its being saturated with water, then the character of the impression has been greatly modified. Under these circumstances, it usually happens that the marks of the fore-feet have been obliterated, while the hinder ones consist of a series of steps, with a rounded outline in front, and gradually becoming shallower behind, until they are each about the level of the face of the stratum receiving the impression, *and the back-part* of the footprint is commonly lost sight of.

The absence of the impress of the fore-feet in beds which have originally been saturated with water, appears to arise from the circumstance that these animals in their progression caused their hinder extremities to form a deeper impress than the fore ones; and this affords another proof of the universality of the laws of nature, not only so far as present existing races are concerned, but likewise during periods long antecedent to the present order of things; for it is a fact that all walking animals have their posterior extremities so organised that in them shall reside to the greatest extent the power of progressive motion. The impressions are usually found in the most beautiful state of preservation when they occur either on the surface of a bed which contains a small portion of clay in its composition, or on a thin deposit of clay itself. When either of these is the case, the impress of each pair of feet is distinctly seen, shewing the form and arrangement of the toes or claws, and the hinder pair of steps are generally more perfect than the fore ones, which have often become partially obliterated by the hind feet treading upon the impressions caused by the fore ones. The reason why the footprints in this substance are in so perfect a state, is owing to the clay preventing the sand from falling into the impressions, and the nature of the matrix receiving the steps is such as to afford a soil sufficiently soft and yielding to receive a perfect impress, and, at the same time, sufficiently tenacious to retain all the fine traces left by the step after the foot had been withdrawn from the impression. The circumstances attendant on the occurrence of footprints when they are met with in this matrix, are such as appear most favourable to the perfection of impressions.

The different states of preservation in which the impressions occur, furnish us with important information concerning the nature and condition of the surface over which the reptiles passed. In the imperfect traces which are found, not only on the surfaces of some of the strata, but also in the interior of the stone when this is split along the laminæ of its bedding, we have evidence of a soft sand not cohesive enough to retain distinct forms of footprints. In those impressions which have a rounded outline, we see a surface which at one time was yielding and tremulous, representing the quicksands of our modern shores. And in the clayey deposits we find the action of quiet water, such as at the present time causes the muddy silt which occurs scattered in patches along a sandy coast. Such conditions and such results now prevail between tidal levels; and such conditions and such results have prevailed, under similar circumstances, along the ancient shores of the sea, long prior to anything to which our ideas can attach when we talk of antiquity—conditions which appear to be almost contemporaneous with the existence of animal life.

Concerning the animals which have produced these ichnolite tracks, they seem to have been not only of different forms, but likewise to have been of various natures, according as they existed during the periods when the trias was being deposited. Those impressions which first attracted attention have been assigned by Professor Owen to Chelonia, and, from the equal size of the pairs of feet he refers these footprints to Testudiniæ, rather than to Trionicideæ, the other two forms of tortoises which might have been supposed to produce impressions. These steps, which occur in great abundance in the quarry of Corncockle Muir, Dumfriesshire, have been distinguished by the name of *Testudo Duncani;* but as the generic appellation is used to designate the existing forms of land-tortoises, Sir William Jardine has substituted in its place the name *Chelichnus.* The same locality which furnishes the impressions of the *C. Duncani*, also affords another form somewhat allied to this species; but the steps being of much more gigantic proportions, this form has been termed *C. giganteus* by Sir William Jardine, and its specific characters are such as at once to separate it from the small species. Other reptilian forms of footprints are obtained from this quarry: there is, however, considerable difficulty in making out the relation which these form of steps bear to existing families; but in other parts of Dumfriesshire there occur associated with the impressions of the Chelichnus tracks of both Lacertian and Batrachian animals, and these appear to occupy a position similar to those which are found at Corncockle Muir.

These Lacertian and Batrachian impressions from the *trias of Dumfriesshire* differ in some respects from those which this formation contains in other localities; and the position in which they occur in the Variegated sandstone in this county, is such as to lead to the conclusion, that here they occupy a lower zone than any which have hitherto been found in the Variegated sandstone. In the Cheshire beds of new red sandstone, we also find impressions caused by Chelonia apparently allied to the genus Chelichnus, and, along with this step, we have the footprints of the Lacertians in the form of the Rhynchosaurus; and also of the Batrachians, as represented by the tracks of the Cheirotherium. All these forms are seen associated in the new red sandstone of Weston Point, where they are seen in the form of natural casts on the under surface of one of the beds of sandstone lying upon a thin deposit of red clay, over which these animals had formerly traversed. Impressions of the Rhynchosaurus are also obtained from the trias of Warwickshire, and elsewhere in this deposit in England. In Cheshire, the highest beds of the Variegated sandstone contain commonly only the steps of the large Cheirotherium, and this form of step is frequently seen in the higher beds of this deposit on the continent. It would appear that during the epoch occupied by the deposition of the Variegated sandstone, there had been three distinct creations separated from each other by certain periods, during which more than one species of reptiles have ceased to exist. First and lowest, there was the epoch of the Chelichnus, the Herpitichnus and the Lacertians and Batrachians, which inhabited our earth in the earliest epoch of the trias, and which had, to a great extent, disappeared when the next form, the Rhynchosaurus, makes its appearance. This Lacertian type occurs in the greatest abundance during the interval which separates the Chelichnus and its contemporaries from the era of the Cheirotherium; and this latter form occurs usually in the higher beds of the Variegated sandstone, where it is interstratified with beds of blue, red, and white clays, a circumstance which shews an approximation to the superior deposit of the trias,—the Keuper. It would, therefore, appear that in Dumfriesshire there existed reptilian forms previous to those which have impressed the sandstone of England with their footsteps.

The Tortoises, the Lizards, and the Batrachians, which at this epoch occupied places on the surface of the earth, must, from their nature, have been different in their habits as well as in the localities where they had their abode. And although we meet with the impressions of these various reptiles under circumstances remarkably similar, and even in some instances associated together, yet it by no means follows that all the reptilian forms of life were of such a nature as to occupy the same habitat, and require the same conditions and food for their existence and development.

With respect to the Chelichnus, we have already seen that, from the nature of its footprints, Professor Owen regards it as allied to the land-tortoises. With such an affinity it is difficult at first sight to perceive how it came to leave so abundant traces of its former existence on what was originally the sand of the sea-shore. The nature of its food, as well as that of the land-tortoises now occurring, must have been derived from the herbage which clothed the adjoining land, and the frequency of its tracts indicates that its presence on the sea-coast was not a matter of comparative accident, but for the purpose of fulfilling some object connected with its natural economy. Sir William Jardine has remarked, that in the impressions of Corncockle Muir, the tracks generally run from west to east, or in a direction which appears to have been from the water towards the land. Occasionally tracks may be found running in an opposite direction, but these are commonly faint and imperfect; and Sir William is of opinion, that the perfection and regularity of the tracks in one direction is owing to the circumstance, that the receding tide had so saturated the sand with water that the impressions became obliterated as soon as made, while on the return of the animals sufficient dryness enabled the shore to retain more distinct footprints. The uniformity in the direction of these tracks seems to point out to something connected with the mode of life of the types of Chelonia, which, during the epoch of the new red sandstone, were inhabitants of Scotland; and it is probable that the forms of land-tortoises which at this time exist, have something connected with their economy which will afford an insight into the moof worm casts, and the occasional occurrence of tracks caused by wandering molluscs, point out the former existence of animals which have left no trace of the organised forms; and but for these results of their mode of life we should have been in ignorance of their having been occupants of the shore in the era of the Variegated sandstone. The occurrence of ichnolites is abundant evidence of the former existence of the animals which caused them, and it by no means follows that because we have not sufficient, either in the form of organic remains or in tracks, or other evidence that no other animals co-existed with the Cheloniæ, the Sauriæ, and the Batrachiæ; and this may arise from the circumstance, that these animals were incapable of leaving such evidence, for it is only from animals furnished with feet that we can expect footmarks, or from worms or wandering molluscs that we should have tracks. The absence of organic fragments from the Variegated sandstone is in all probability owing to this deposit being of such a nature as to be hostile to their preservation. The large quantities of peroxide of iron which abounds in the sandstone of its bed must have exerted an injurious influence on any organic bodies which may have been contained therein. Animal or vegetable matter, subjected to the agency of this substance, is rapidly decomposed, the peroxide of iron furnishing an equivalent of oxygen to aid in the decomposition of carbonaceous matter, which, being converted into carbonic acid, unites with the protoxide of iron, forming carbonate of iron, which, on exposure to the atmosphere, is rapidly converted again into peroxide, and is in this state again in a position to effect a further change on other organic substances. By this means the carbonaceous portions were doubtless removed from the bones which may have been buried in the sand, and the percolation of water charged with carbonic acid, would speedily remove all traces of calcareous matter. It is probable that to these circumstances we owe the absence of organic remains in the Variegated sandstone. And the same circumstances, where they have occurred, would also deprive other formations of their organic contents. *Sandstones*, generally, are deficient in organic remains, and this perhaps arises from the porous nature of this substance, as well as from the action of oxide of iron; for the arrangements of the particles in these deposits are such as to allow free access, both of atmospheric air and also of moisture, which would soon obliterate all traces of these organisms; while in deposits, where they have been rapidly covered with mud or any substance impervious to air, these would remain little changed, and capable of furnishing information concerning the creatures of which they formed a part.

Had it not been for ichnolite impressions we should have been induced to conclude that the presence of reptiles in formations anterior to the lias was so rare that these animals existed only to a small extent. With regard to chelonia, without footprints we should not have been aware of their occurrence; and when we reflect on the conditions necessary for the receiving and retaining of tracks, as well as that such tracks have been made only in a littoral zone, we must arrive at the conclusion, that negative evidence, so far as regards geological formations, will not enable us to say that certain classes of animals had no existence, because we find neither organic remains nor footprints. The nature of almost the whole of the deposits which constitute the geological formations is such as to indicate that these have originated from the sea, and it is rarely that in these marine beds anything is met with to shew what was the nature or form of the inhabitants of the land which was above the surface of the sea during the different epochs.

That dry land existed at an early period there can be little doubt, and it is equally probable that this dry land had its occupants as well as the waters of the ocean by which it was surrounded. What the nature of these occupants may have been during the time when the Variegated sandstone was being deposited we have at present no means of arriving at, except that the land-tortoises, which have left the impress of their footsteps on this sandstone cropped the vegetation which clothed the soil, and drank of water which drained from the surface of this land. The recent discovery of a fossil tooth in the trias, of a form shewing that its possessor must have been a mammifer which was probably insectivorous, gives us the earliest evidence of the existence of mammalia; and although this tooth appertains rather to the Keuper than to the Variegated sandstone, it shews that highly organised beings were inhabitants of our earth at a period little posterior to that when Tortoises, Saurians, and Batrachians tenanted the land and sea-shore.

The absence of any deposits of a fluviatile nature, in any of the older formations is doubtless the cause of the want of evidence concerning terrestrial animals in the older epochs. It is only from such fragments as by accident find their way into the rivers and streams draining the solid ground, that we derive any information of the occupants of the land; and even this circumstance, as well as the numerous causes which operate to aid and assist in the destruction of the fragments which by accident find their way into the water, tend to render the occurrence of these fragments in the solid crust of the earth a matter of great rarity. During the period of the deposition of the trias, there is every reason for believing that an abundant and luxuriant vegetation prevailed; and that this was of such a character that its foliage was well capable of being preserved. Yet although the Variegated or Bunter sandstone has been extensively wrought in Great Britain for building purposes, it has never furnished any distinct trace of the vegetation which at this period obtained on the earth's surface. Even in our own time, the foliage which each year is cast from the vegetation now prevailing so entirely disappears, that it is only under some peculiar circumstances, that we find any well-marked traces of it after a short time; therefore we can seldom expect to find such evidence of terrestrial inhabitants, which at remote epochs have been tenants of the land, in any of the deposits which have resulted from marine agency. On the whole, it would appear that the fossil remains which occur in the various strata are an exception to the general rule, which indicates that the destruction and disappearance of organic forms prevailed more particularly, so far as terrestrial beings were concerned.

We may therefore conclude, that along with reptiles, other creatures of a higher organised type occurred, and that these fulfilled the objects, and occupied the places, of such mammalia as now prevail;—that along with the Lizards and Batrachians inhabiting the triassic shore, birds which probably represented the sandpipers of the present day existed, and found their food amongst the shallows and mud of this ancient beach.

The occurrence of ichnolites in the Potsdam sandstone, the base of the American Silurians, goes a long way towards overthrowing the opinions which have been entertained, that in the older formations organic forms were of the lowest types. And when we reflect that these formations are exclusively of marine origin, the cause of the generally low development of the remains at once presents itself. In the case of the footprints, these are not such as to ally the Cheloniæ which formed them with those which impressed the Variegated sandstone. The impressions of the Potsdam sandstone have relation rather to Emydia than to land-tortoises, and in these impressions we have indications not only of an exalted form of animal life, but likewise of one inhabiting either an estuary or fresh water; and from this circumstance we may infer that the drainage water of the land found its way at this early period to the sea, and as there was an estuary and fresh water, so there must have been dry land, which had probably its inhabitants, concerning which we are at present in total ignorance. The ichnolites of the trias afford evidence of an important character, so far as the creation and existence of organic forms are concerned. In the low beds of the Variegated sandstone, as they are developed in Dumfriesshire, we have the impressions of several species of Cheloniæ, Sauriæ, and Batrachiæ, differing in their footprints, and consequently in their nature, from those which have been found in the higher beds of this formation at Weston Point, Cheshire. At this locality, however, we meet with occasionally the impression of a small tortoise, which appears to be allied to one of the small impressions of Dumfriesshire. On the whole there is still sufficient to shew that different types inhabited the shore here; and as there are certain indications that at Weston Point the sandstone occupies a higher position than the beds which in Dumfriesshire furnish impressions, we may conclude that at the former the animals were of a newer creation, and also that many species which had inhabited the Variegated sandstone shore in the latter locality had ceased to exist prior to the creation of some of the reptiles which have left their tracks on the beds at Weston Point. The footprints which have been obtained from the white sandstone of Stourton and Lynne differ likewise from those of Wester Point; and as these beds indicate an affinity to the Keuper we may infer that in them we have also evidence of a creation of species of reptiles appertaining to the base of the trias, subsequent to that which called into existence the reptiles which impressed the Weston Point deposits; and from these localities in the Variegated sandstone, viz., Dumfriesshire, Weston Point in Cheshire, and Stourton in the same county, we derive information which leads to the conclusion that three epochs of creation prevailed during the deposition of the Variegated sandstone.

The creation and destruction of species, are matters which are involved in considerable obscurity. The present forms of organisation which occur, are, in some cases of extension, geographical distributions, and in others are in a great measure local. In the former case, forms appear to have been transported from one country to another, by means of which we have at present no evidence. In the continents of Europe and America, we have species of vegetables common to both, and yet we have no means of ascertaining how this came to take place, except by conjecture, which would lead us to conclude that at a period anterior to the mammalia which now abound on both continents being called into existence, the two continents were connected together, but were severed before the animal forms of the present time were created. For if this had not been the case, it would be difficult to conceive why we should not have a resemblance in animal as well as vegetable species. This conjecture as to the reason why in Europe and America we have some forms of vegetables similar in species, is supported by the fact, that, at an epoch slightly anterior to our own, the fauna of Europe, Asia, and America, possessed several species common to these different continents. Indeed, at this period it seems that the fauna of these continents had a more intimate connection than that which now obtains in the two portions of America separated by the narrow isthmus of Darien. Probably the vegetation which has in part its representing species in Europe, is a portion of the flora of this epoch; and it would seem that such plants as are exclusively American, have had a more recent specific origin.

This leads to the conclusion that such plants as are of extensive distribution had an existence anterior to our present fauna; and that certain vegetables were older than mammalia might be expected, inasmuch as this prior existence was necessary in order that herbivorous quadrupeds might be supported. The faunas and floras which now exist are made up of animals and vegetables as widely differing from each other as the areas these occupy are remote. The animals and plants of America have, on the whole, not only a specific but generic character peculiarly their own, and the same remark applies to other large districts of country. In Australia the fauna is very imperfect, being represented by only two families, the Marsupials and Rodents; and in many of the large islands of the Pacific it is questionable whether Mammalia has any aboriginal representatives, such forms as are met with having probably been introduced by the aid of man. With districts having distinct faunas and floras, and with the probability that such species of plants as have extensive geographical distribution, are of a more ancient origin than those having a local habitat, we may infer that the forms making up the faunæ as well as the floras which now prevail, were not called into existence at one period, because such a supposition would lead to the conclusion that the different continents made their appearance above the surface of the water at the same time, or else that large tracts of land existed above the surface of the sea unoccupied for a considerable time by any inhabitants; a circumstance which is contradicted by the evidence which all the geological formations afford. It is probable that in the case where one portion of land became detached from another, that it would retain for a while all the plants which flourished upon it when forming a portion of the land from which it was separated. But the separation itself would produce climatic influences, such as would ultimately prove destructive to many forms of vegetation, leaving only such plants as were capable of enduring the new conditions produced by the separation; and as we find distinct specific forms both of plants and animals occupying the detached land, so we are induced to infer that these have had their origin in distinct specific creations adapted for the conditions under which they were placed. With regard to the disappearance of species, although there can be little doubt that in some instances unfavourable circumstances such as we have supposed may have operated in the destruction of some, yet, still, there is reason to believe that unfavourable circumstances alone have not produced the destruction and disappearance of the numberless species of organic forms which have been occupants of the earth since the first creation of animal life, until the present day. In the different geological formations, which are each marked by organisms peculiar to some extent to itself, we find, with a few exceptions, that animal forms rarely disappear suddenly. We perceive them on their first occurrence few in number, but gradually increasing until they attain the maximum development, and from this they by degrees lessen in quantity until they at last disappear, waxing and waning like the monthly moon. It would seem from the information which we derive from geology, that there is an innate principle of decay in species, as well as in the varieties which are obtained from them. Perhaps the rapid tendency of varieties to disappear, results from the specific principle of decay acting with greater vigour in these forms which possess a modification of the specific characters. It would seem also, that the creation of a species has not usually followed the destruction of another, the place of which it was to occupy; but rather that after the maximum development had been attained, the new form makes its appearance, gradually filling up the void caused by the decline of its predecessor. Neither does it appear, that a species which has once become extinct, is ever revived; the Creator manifesting the illimitability of his power, by calling into being new forms whenever he found it desirable. That species have disappeared, and had their places filled by new creations, the history of every geological epoch testifies; and that those living things, whether plants or animals, which now possess the surface of our globe, were called into being at various periods, is exceedingly probable; and if we are to judge of the future by the past,—and the unalterable nature of the laws which govern both organic and inorganic substances, justifies this mode of judging,—then we may infer that new forms, both of plants and animals, will at future eras be tenants of the earth which we now call our own. By applying similar principles to the epoch of the trias, we shall find in the portion which is represented by the Variegated sandstone, the creation and the probable dying out of species, owing to the operation of those laws which have governed the creation and destruction of organised beings. We have from the surface of the beds of the red sandstone, evidence not only of animals which traversed this substance when in a sandy state, but likewise of the physical conditions, and also of the atmospheric influences which prevailed. The pitted faces of some of the beds tell of the pelting shower, and the nature and direction of these pittings shew from which quarters the storm-driven shower came; and the rippled markings which are seen on some of the beds, lead us to look backward into the abyss of time, to the wandering wave dancing in the sunbeam, or lashed into billows by the fury of the storm king. The impressions on the new red sandstone lead the mind to an epoch so far back in the history of the earth, that we fail to have any adequate idea of the distance of this, so far as the means by which we compute time. Yet, however remote this epoch may be, it is marked by those phenomena and circumstances, which shew that the laws of nature are immutable, and that such causes were in operation as those which prevail at the present time.

The beauty and perfection in which these footprints occur, is such, that were it not for the hardness of the stone, we might be induced to look forwards along the track for the animal which produced the impressions of which none of the solid parts remain, the footprints being its sole relic. Time, with its ruthless hand, has destroyed the monuments which man erects, to hand down to posterity the records of greatness; it has swept from the face of the earth all traces of the progress of mighty conquerors, and buried in oblivion the havoc, the slaughter, and the plundering of the oppressor, and yet it has left the evidence of the peaceful wanderings of the tortoise, and the footprints of other reptiles, made during a period long prior to what we term antiquity.

> "It is well to scan,
> What's writ on this neglected stone."

How easily the mind is led to revive in its chambers the scenes which occurred when this red sandstone formed a portion of the sand of the sea-shore. To recall the monotonous waste overspread "by ribbed sea-sand," moved and driven by every breeze,—to behold the distant sea, with its wandering waves dancing in the summer's sun,—to see this luminary dipping behind the western waters, and filling the face of nature with the blush of loveliness, becoming gradually more indistinct, as night draws her dark veil over the restless sea; then to perceive the crescent moon silvering the ripples of the coming tide, and hear the distant moan which foretells the brewing storm, and the mourning of the wind in the chambers of the withered shells; and again, to look forward on the western sky and see the dark clouds lower, driven by the storm towards the shore, and transiently dimpling the ocean's cheek with rain-drops until it reaches the sand, where the passing shower leaves more durable impress in the form of the pitting of fossil rain-marks. The laws of nature are beautiful and sublime, telling of the goodness as well as the greatness of the Creator.

Observations on the Temperature of the Sea, made during the Voyage of H.M.S. Rattlesnake, Dec. 1846—*July* 1847. By JOSEPH DAYMAN, R.N., Lieut. and Assistant-Surveyor. (*From Mr John Macgillivray's "Voyage of the Rattlesnake,"* vol. i. p. 329.)

Date.	Position of Ship.		Temperature of Air.	Temperature of Sea.		
	Latitude.	Longitude.		Surface.	Depth in fathoms.	Depth in fathoms.
1846.						
Dec. 17	34° 52′ N.	16° 24′ W.	59°	61°	61° 132	
28	28 34	18 38	66	67	63 130	
30	23 22	20 58	68	69	66 66	61° 190
31	21 13	22 1	66	71	61 193	
1847.						
Jan. 1	18 40	23 18	68	73	70 78	57 178
2	15 28	23 22	72	73	53 180	
3	8 55	22 38	78	82	59 191	
5	6 28	22 39	82	84	51 185	
6	5 54	22 34	79	82	50 361	
7	5 8	22 19	82	83	49 340	
12	1 5	22 32	77	83	52 335	
14	2 37 S.	26 15	79	80	53 268	
15	5 9	27 51	78	80	54 153	60 293
16	7 55	29 11	79	80	53 183	47 273
17	12 49	32 23	79	81	80 59	
19	15 5	34 44	79	80	59 226	62 317
20	17 48	36 20	80	81	67 132	
21	20 10	37 58	78	80	59 146	50 306
Feb. 4	26 7	40 30	66	77	60 231	51 351
5	27 21	38 1	73	76	65 182	51 342
8	30 52	36 48	71	73	61 200	51 360
9	33 22	36 54	68	70	60 184	50 324
10	35 21	35 31	68	68	62 168	49 309
12	37 20	30 58	69	66	57 205	45 355
13	36 50	27 50	66	66	62 215	45 370
15	36 31	24 7	63	64	58 194	45 339
16	36 7	21 4	59	66	55 196	47 336
17	35 30	19 34	64	69	58 215	61 366
18	36 47	18 47	64	68	57 128	50 257
19	38 7	16 43	65	63	48 370	
21	37 54	10 28	59	62	53 205	43 345
23	36 4	4 53	62	67	61 205	48 345
24	34 42	4 15	69	70	51 364	44 650
25	35 28	3 6	68	69	54 195	46 335
26	36 57	1 31	65	67	53 195	49 335
27	38 22	0 28	64	62	55 192	45 338
March 1	38 25	4 1 E.	56	55	48 195	44 335
3	36 47	10 24	63	66	54 208	46 348
4	36 41	12 1	66	64	55 188	46 328
5	36 22	13 40	66	68	52 217	46 367
6	36 24	14 42	71	70	65 147	56 284

Date.		Position of Ship.		Temperature of Air.	Temperature of Sea.		
		Latitude.	Longitude.		Surface.	Depth in fathoms.	Depth in fathoms.
1847.							
April	13	36° 17′ S.	26° 43′ E.	61°	68°	62° 215	60° 360
	14	36 53	27 49	66	69	65 215	56 360
	15	38 10	29 39	67	69	67 205	58 350
	16	38 8	32 54	69	69	64 128	60 278
	19	37 49	39 50	64	59	51 266	53 316
	21	38 13	45 36	66	60	55 158	52 293
	24	34 24	54 14	60	64	60 157	58 287
	26	30 13	56 50	65	71	61 162	60 283
	27	28 16	57 18	70	73	60 210	57 360
	28	26 56	57 31	70	74	60 200	57 350
May	1	25 48	61 6	74	—	62 165	59 320
	3	20 42	58 47	76	77	74 140	57 300
	18	21 53	56 45	77	77	63 182	
	19	24 16	56 58	76	75	71 182	
	20	26 9	58 45	74	71	63 140	73 360
	21	27 36	61 9	69	73	54 333	
	22	28 6	63 30	68	69	53 300	
	24	28 1	67 28	67	69	54 286	
	[illegible]	32 4	68 14	66	66	54 360	
	27	33 48	70 11	65	65	55 340	
	28	35 33	72 6	63	63	54 350	
	29	36 6	74 15	60	60	55 350	
June	1	35 0	80 56	61	59	52 350	
	6	36 42	97 54	55	56	55 346	
	12	39 57	118 0	48	54	51 320	
	14	40 46	123 26	49	53	45 320	
						50 380	
July	9	15 miles E. of Cape Phillar, Van Diemen's Land.		53	55	48 375	

Singing Birds and Sweet Flowers in Jamaica.

(Continued from page 33.)

But there is one master musician, whose varied notes lea[illegible]ll[illegible]ve the efforts of his rivals at an immeasurable distance behind him. [illegible] It is he that makes our sunny glades and shady groves eminently [illegible] melodious, by night and day, sustaining almost the whole burden [illegible] himself.

He is the nightingale of the Western World, the many-voiced Mocking-bird, (*Mimus polyglottus*). Abundant in almost all situations, from mountain-peak to sea-shore, but especially common in the orchards and about the homesteads of the lowlands, the voice of the Mocking-bird is heard all through the year, even when other birds are silent; and all through the day; and that not by ones or twos, but by dozens and scores, each straining his melodious throat to outsing his rivals, and pouring forth his full expressive strains in all the rich variety for which this inimitable songster is so famous. Wilson has truly observed of this delightful bird, that "the ear can listen to his music alone, to which that of all the others seems a mere accompaniment." If all the birds of Jamaica were voiceless except the Mocking-bird, the woods, and groves and gardens, would still be everywhere vocal with his profuse and rapturous songs.

In those brilliant nights, when the full-orbed moon shines from the depth of the clear sky with such intensity that the eye cannot gaze upon the dazzling brightness of her face, shedding down on plain and sea a flood of soft light sufficient to enable one to read an ordinary book with ease in the open air,—how sweet, how rich, how thrilling, are the bursts of melody that rise from the trees around, the serenades of wakeful Mocking-birds. Nothing to be compared to it have I ever heard in England; the night-song of a single bird, however fine may be its execution, is no more to be put in competition with such a chorus, than the performance of a single musician, though a master, with that of a band. Nights so lovely are seen only in the tropics, and the music is worthy of the night.

The Water-Thrushes (*Seiurus*), one of which at least is said by Wilson to be so exquisitely sweet a songster, that he was never tired of listening to it, though common in Jamaica during a portion of the year I have never heard sing, perhaps because the months that they spend in the island are those of autumn and winter. But the Wood-Thrush (*Turdus mustelinus*), or May-bird, as it is provincially called, is recognised as a songster rivalling even the Mocking-bird in the brilliant execution of its melody. This sober-coloured, but delightful bird does not extend, so far as I am aware, to the neighbourhood of the Bluefields, in its transient vernal sojourn; but confines itself to the sea-side groves and plains of the windward end of the island.

Besides all these, which, in various measure, perform their parts in the music of our woods, and not to mention the multitudes of Warblers, and Flycatchers, and Finches, whose notes, insignificant in themselves, help to swell and vary the general harmony,—there is another series of voices that must by no means be overlooked in an enumeration of our woodland music,—the plaintive cooings of our numerous wild doves. In the recesses of the mountain forests, the silence is broken by the loud hollow calls of the Ringtail and Blue Pigeon (*Columba Caribbea* and *rufina*), and by the mournful cadences of the lustrous Mountain-Witch (*Geotrygon sylvatica*). The woods, that densely clothe the inferior summits, and sheet the sides of the sloping hills, resound with the energetic coo of the Baldpate (*Col. leucocephala*), the short reiterated moaning of the Partridge Dove (*Geotrygon montana*), the querulous call of the Ground Dove, (*Chamæpelia passerina*), and the tender, melancholy, sobbing fall of the gentle Whitebelly (*Peristera Jamaicensis*).

But as it is in the lowland plains and cultivated estates that we most abundantly hear the melody of singing birds, so here do the plaintive voices of the doves fall most frequently upon the ear. The Whitewing (*Turtur leucopterus*) and the Pea-Dove (*Zenaida amabilis*) are essentially lowland birds; and these, with the exception of the Whitebelly, are the most incessant and the most tender of all our cooers. Not, however, that we hear their voices immediately around the homestead; when they come into the open pastures to feed, they are usually wary and silent; but from the surrounding woods, the tall thick trees of the fens, and especially the impenetrable mangrove morasses, their loud, but sweetly gentle, moanings fall with mournful, pleasing cadence upon the ear. The Pea-Dove's voice is the more tender, and is particularly prominent in the evening, while the blustering sea-breeze gradually lulls itself to repose; the longer, sharper, and more impatient call of the Whitewing is most heard in the morning, though each season brings the notes of both birds from all parts of the woods around. They are respectively characteristic of the quietude of the late and early hours.

None but those who have listened to these gentle voices can tell what an effect they produce upon the mind. Their tender melancholy communicates itself to the hearer; and though reason tells him that they are the expressions of buoyant joy and health, he can scarcely fail to feel a pang of sympathy for what seems to be the complaint of gentleness in distress.

Nor is it true that our groves and fields are destitute of fragrance. In spring the oranges and limes that are planted in such profusion upon every estate, both in mountain and in plain, and even border the public roads, are covered with their abundant blossom, and the air all around is loaded with the richest perfume. So it is in the upland districts, when the coffee plantations are in bloom; the flower of which tree is as fragrant as it is delicately beautiful. In the edges and borders of woods, there is a common shrub called Wild Coffee (*Tetramerium odoratissimum*), nearly allied to the cultivated species botanically, as it is both in beauty and fragrance. Butterflies, moths, bees, and flies, throng around its lovely white blossoms, the delicious and powerful odour from which is diffused to a great distance.

I have observed that many flowers in Jamaica possess the aromatic odour so much admired in our pinks and carnations, that of the clove. The beautiful plants called the red and the white Spanish jasmine (*Plumæria rubra* and *P. alba*), common shrubs, whose thick stems, leathery leaves, and noble spikes of blossom, form so striking objects in the smaller woods, have this odour. I found it in the blossom of a species of *Pancratium*, with small bulbs and large oval leaves, growing on the St Elizabeth Mountains; the fragrance, which was very abundant, I should not have been able to distinguish from that of a carnation. That gorgeous flower, the

Nightflowering Cereus (*Cereus grandiflora*) is another notable example of the same prevalent odour. The long, trailing stems of this cactus are very commonly seen in the lowlands, sprawling to a great length over the stone fences, hanging in irregular festoons from the forks and limbs of the trees, the great cotton tree in particular, and intertwining its tough and prickly vines among the shrubs, helping to give the woods that formidable, repellent, impenetrable character which a tropic "bush" is known to present. The magnificent flowers are, however, rarely seen; the plant seems to be a shy bloomer, and, when the blossoms do meet the eye, it is in nine cases out of ten either as unexpanded buds, or in that miserable drenched condition which the flowers of a cactus always assume when fading, looking exactly as if they had been dragged through boiling water. In order to see it in perfection one must make it open in the house, or visit it at midnight, which is inconvenient. I have several times marked a maturing bud, and, when it appeared nearly ready to burst, cut a few inches of the stem on each side and brought it within doors. Soon after dark it begins to open, and towards midnight expands in its noble beauty; a disc, six inches in diameter, very double, the exterior rows of petals of a yellowish-brown hue, gradually paling in tint to the centre, where the petals are of the purest white. Meanwhile the delicious clove-like perfume, is diffused in such abundance that a delicate person can scarcely sit in the room, and the very house is filled with it from one end to the other. In the morning beauty and fragrance are both gone, and the blossom, lately so gorgeous, possesses no more of either than may be pretended to by a boiled cabbage.—(*A Naturalist's Sojourn in Jamaica, by P. H. Gosse*, p. 170.)

On the Distribution of Manganese; on the Existence of Organic Matter in Stalactites forming Crystallised and Amorphous Crenate of Lime. By DAVID A. WELLS, Cambridge, Mass.*

1. *On the Distribution of Manganese.*

The occurrence of pebbles and water-worn stones in many of the streams and water-courses of New England, which have their origin among, and run over, igneous and metamorphic rocks, is by no means uncommon, and has doubtless attracted the attention of every observer. When the bed of a stream in which they occur is examined, the coloured pebbles and stones will be found at intervals, generally after or below a fall or rapid, and not immediately above,

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* Silliman's Journal, January 1852.

This colouring matter, which is wholly superficial, and of different degrees of lustre, is due to an incrustation of the black oxide of manganese, and occurs independently on almost every variety of stone.

In Jameson's Edinburgh New Philosophical Journal, for July 1851, Dr John Davy calls attention to somewhat similar incrustations in England, of which he says as follows: "Though always superficial, in one spot the incrustation is so thick as to be available for use; and in this instance the black oxide of manganese acts as a cement, forming a bed of conglomerate, several feet thick. Whence this incrustation is derived, or how produced, is not obvious. Restricting the view to the spots where it occurs, it might be supposed to be a deposit from running water. But when it is seen that the colouring matter is not to be detected on rocks *in situ*, the fixed rocks in the course of the stream, the idea ceases to be tenable, and the inference seems to be unavoidable, that the sand, pebbles, and stones, so coloured, have been incrusted with the oxide before they had been carried down to the spot where they are found loose, or when in the form of conglomerate, that the cementing oxide has been brought by water exuding from some rock or stratum containing manganese in a minor degree of oxidation, and acquiring the higher degree by the absorption of oxygen, and at the same time the cementing quality." Dr Davy also infers that manganese exists in the vicinity of these incrustations in large quantities, and advises special inquiry in search of it.

Before the publication of the article referred to by Dr Davy, the subject of these incrustations had attracted the attention of Dr A. Hayes of Boston and myself, and we believe the following to be a full and satisfactory account of the origin of this phenomenon:—

The manganese exists in almost all the igneous and metamorphic rocks of New England, and I may say in other parts of the world, generally as a double carbonate of lime and manganese. When the waters of the springs, brooks, and rivers, flowing over these rocks, become changed with soluble organic matter, in the state of crenic, apocrenic, or humic acids, drained into them in consequence of rains or inundations, from swamps and peat meadows, the carbonates of lime and manganese enter into solution. At such times manganese may generally be detected in these waters, as has been done by Drs C. T. Jackson, A. A. Hayes, and others. When the water holding the manganese in solution becomes broken and thrown up in the passage of falls or rapids, consequently exposing it to the influence of the atmosphere, the manganese passes from a low state of oxidation to the insoluble peroxide, and is deposited for a considerable extent upon the rocks and pebbles below. It will thus be found upon examination, that at intervals in the bed of the stream, the stones are completely blackened or discoloured, while in the other places no such *depositions* exist. Beautiful examples of this phenomenon may be seen at some points on the Merimac River, and indeed in almost every rivulet in New England.

I have also noticed similar depositions between the divisional strata planes of sandstones in the valley of the Connecticut, thus shewing, that apparently the same agencies were at work during the deposition of these rocks as at the present day.

2. *On the existence of Organic Matter in Stalactites and Stalagmites, forming Crystallised and Amorphous Crenate of Lime.*

In the eighth chapter of Liebig's Agricultural Chemistry, edited by Playfair, there is given the result of some examinations of stalactites, from caverns in Germany, and from the vaults of old castles upon the Rhine, made with the view of ascertaining the fact of the presence or absence of organic matter in these bodies, either combined or uncombined.

The result may be stated in the words of the author, Professor Liebig. The stalactites from the caverns "contain no trace of vegetable matter, and no humic acid, and may be heated to redness without becoming black. In the stalactites from the vaults and cellars of old castles," he says, "we could not detect the smallest traces of humic acid." There could scarcely be found a more clear and convincing proof of the absence of the humic acid of chemists, in common vegetable mould." Under the term humic acid, Professor Liebig undoubtedly means to include all those organic acids arising from the decomposition of vegetable matter, and which have received the names of crenic, apocrenic, geic, and humic acids.

Having been informed by Dr A. A. Hayes of Boston, that he had, in numerous examinations, arrived at results directly opposed to those of Professor Liebig, I was induced, at his suggestion, to make an examination of a large number of stalactites and stalagmites, obtained from various localities, with reference solely to the presence or absence of organic matter in these bodies.

The specimens examined were all from caverns or rock formations, and were obtained from various parts of the United States, from Trieste in Austria, Malta, and the Sandwich Islands. In colour, they varied from an almost pure white, to red, yellow, and brown, of different shades; and in crystalline character, from a structure resembling Arragonite, to a variety entirely wanting in symmetrical arrangement, or a mere incrustation. The specimens were dissolved in diluted hydrochloric acid, the flocculent matter separated, collected and washed, boiled in caustic potassa, carbonate of ammonia, or carbonate of soda, and then tested in the usual way for crenic and apocrenic acids, by acetate of copper and carbonate of ammonia. In all the varieties, with one exception, abundant flocculent organic matter was separated, which, on testing, gave evidence of crenic acid in considerable quantities, with doubtful traces of apocrenic acid. The exception alluded to was the specimen examined from Trieste, which did not afford any appreciable flocculent matter, on dissolving in acid. The greatest quantity of organic matter was found in stalactites of a deep yellow colour, highly crystalline and uniform in character, and in the portions examined perfectly homogeneous, and free from layers or intervening bands, indicating different periods and changes in deposition. As the presence of iron could not be found in the acid solution, it is inferred that the colour of these yellow stalactites must be owing, in great part, to combined organic matter, existing as crenate of lime. In specimens, like the spar ornaments from the Rock of Gibraltar, with which all are familiar, the colouring and delicate shading is also probably due to organic matter.

Dr Hayes informs me that he has also found organic matter in Arragonite, in sufficient quantity to separate in flakes, while the specimen was dissolving in acid.

From these statements it must, I think, be inferred, contrary to the view of Liebig, that organic matter does exist in stalactites generally, as an acid combined with the lime, and imparting to them their various colours. I would by no means call in question the accuracy of the experiments of Professor Liebig, further than that, as far as my observations extend, crenic acid in the presence of lime, and combined with it, passes over like oxalates, upon heating, into carbonates, without perceptible blackening.

It may be here added, that Professor Johnston of England describes a compound of alumina with crenic acid, occurring in caves of granite upon the coast of Cornwall. This mineral has received the name of Pigotite, and is observed in places where the surface-water trickles down over the granite rocks. From this it may not be inappropriate to apply the term *crenite* to those lime formations in which crenic acid occurs in considerable quantities.

Results similar to those announced above, have been obtained by Dr C. T. Jackson, as well as by Dr Hayes of Boston. Dr J. Lawrence Smith informs me, that he has frequently met with crenic acid in lime concretions from Asia Minor, and its existence in stalactites was also announced by Dr Emmons of Albany, some years since. My results can therefore be considered but as the verification of those obtained by others.

Obituaries of Oersted, Morton, and De Savigny.

1. *Hans Christian Oersted.*

The name of Hans Christian Oersted, the discoverer of electro-magnetism, has been added to the long list of those [illegible] continental science has recently been called upon to whom [illegible] mourn. It has been truly said of him, that the position which he occupied in Denmark was very similar to that of Humboldt in Germany. He was the philosopher, man of science, the scholar,—the kind friend of youth the judicious counsellor of age,—one whom monarch and citizen alike delighted to honour. Oersted was born August 14, 1777, in Rudkjöbing, a small town on the Danish island of Langeland. The poverty of his parents and the isolation of their little village were alike unfavourable to the attainment of a thorough education. But Oersted, like many of his predecessors in the same path, learned for himself the elements of knowledge, and especially arithmetic, from old school-books which fell in his way, and taught his brother *Anders*, who was a year younger, all that he had thus acquired for himself. And like the brothers Humboldt, the brothers Oersted seemed in after life almost to divide between themselves the realm of human knowledge. While in each case, one brother followed the paths of actual science, and adorned the university and the academy,—the other rose to equal eminence in the other division of human knowledge, and finally became minister of state.

Oersted came to Copenhagen in his 18th year, and devoted himself to his studies with intense zeal. His fellow-student, Oehlenschläger, afterwards the celebrated poet, was at this time almost the only person who shared his friendship with his brother, and the intimate friendship thus begun continued undiminished and uninterrupted till dissolved by death.

In 1799, Oersted published his inaugural dissertation on the "Architecture of Natural Metaphysics," (*Architectonik der Naturmetaphysik*). This treatise shews that, even at that period, his mind was deeply imbued with tastes and sentiments similar to those which characterise the last writings of his life.

At this time he proposed his new theory of the alkalies, a theory which was afterwards universally adopted. In 1800, he was appointed adjunct in the medical faculty of the University, and began to lecture on chemistry and the philosophy of nature.

This was the year in which Volta discovered the battery which bears his name; setting this discovery, as Moller has admirably said, like a milestone at the close of one century and the beginning of the next. All Oersted's energies were immediately enlisted for the new field of research thus opened, and he immediately detected the true law of the decomposition of salts. From this time forward he dedicated himself solely to the career of an investigator, and in the pursuit of his studies visited almost all parts of northern Europe.

His subsequent life is well known to the scientific world. In the year 1820 he discovered the magnetic influence of electricity, thus founding the science of electro-magnetism, and in fact first opening that new course of research into the mutual relations of the several energies of nature, which is still pursued with such brilliant success, yearly leading to more and more astonishing results. Without the discoveries of Oersted, where would have been those of Ampère, Arago, Faraday, Seebeck, and Melloni? In 1814 he established a magnetic observatory at Copenhagen, but has since that time devoted himself to those sciences which spring from the mutual relation of the material and spiritual worlds. His books on "The Spirit in Nature," "Natural Science and Spiritual Culture," "Natural Science in its relation to Poetry and Religion,"—must be and continue classic works, whatever may be individual views of the correctness of their philosophy. The Bishop of Seeland has very recently published a severe attack upon Oersted's views, occasioned by the publication of his "Geist in der Natur." But although Denmark has been one of the last continental nations to learn how little our knowledge of the truth is advanced or facilitated by contests between theologians and men of science, the reception of Bishop Mynster's book shews that the great fact —that the true interpretation of revelations through moral and through physical media, must necessarily coincide,— is now at last appreciated in Denmark also.—(*Professor Silliman.*)

2. *Dr S. G. Morton, author of the Crania Americana and Crania Ægyptiaca.*

[illegible]h sadness we record the death of an eminent man from [illegible]nks of American science, Dr Samuel George Morton [illegible]adelphia. He died on the 15th of May last, in his fifty-third year. The following paragraphs from obituary notices published upon his decease, but imperfectly express our own high estimate of his learning and his many personal excellencies.

Dr Morton was a native of Philadelphia, born in connection, we believe, with the Society of Friends, which has given to it so many citizens distinguished in the walks of science. Adopting the medical profession, which he studied under the auspices of the late Dr Isaac Parish, he received the honours of the doctorate from the University of Pennsylvania, but afterwards proceeded to Edinburgh, where he graduated again with distinction, highly esteemed for his literary abilities, as well as his professional proficiency. Young, ardent, with the enthusiasm of a poetical temperament—for poetry was his first ambition—but a manly sense and purpose that enabled him to postpone the imaginative to the solid and useful, he made the tour of Europe, shook hands with warm friends and relatives in Ireland, the land of his ancestors, where strong inducements were offered to retain him, and returned to his native country, and to his native city, here to commence a career which, even at that early moment, he had marked out, and to build up for himself a name not likely soon to be forgotten. It is scarce necessary for us to refer to the success of his professional, or merely medical career. That was always great. For years, no physician in Philadelphia could boast a larger, few an equal, practice. His claims to distinction, in this capacity, were proved by his well-known work on Consumption, and other valuable publications, as well as by his lectures at the Philadelphia Hospital, Pennsylvania College, and other medical institutions with which he was at different times connected.

One would suppose that, with the burden of his heavy practice, and all the addition of these laborious collaterals pressing upon him, he could find but little leisure for other pursuits, and indulge but small hope of acquiring fame in a different path. His history is an example of what men *can* do, even under adverse circumstances, who are patient, who are resolute, who are industrious, who are wise, who are true to themselves, and sufficient to themselves. Ever calm, but ever active, always prepared for the exigencies of his business duties, and ever ready to devote to profitable use the scanty intervals of leisure which those duties allowed him, he found time in continual participation in scientific affairs, and in the proceedings of the Academy of Natural Sciences, of which he was for thirty years a member, and for many years its Vice-President and President; and, what is more, with the additional incumbrance of this general scientific participation, he found time also to produce those great works, the *Crania Americana* and *Crania Ægyptiaca*, which immediately placed him in the front rank of archæologists and ethnographers throughout the world. The appearance of the first-named of these volumes established an era; it opened a new department of research; it created a new science—one that has done more for the true exposition of human history, the interpretation of the mysteries of race differences and race affinities—far more than anything ever previously effected by the pen of the annalist or the wand of science. Few scientific works ever produced a stronger or more durable impression on the philosophic mind, or have had a more powerful effect in directing the course of future investigations.

But we have no space to write the history or attempt the eulogium of Dr Morton. That task will fall to more competent hands; though it could be undertaken by none who knew him better or prized him more. It will be all the more justly executed where there is a less lively sensibility or less oppressive appreciation of his loss. Let us say of him, only, that he was a good as well as great man; estimable in all his relations; respectable in all he thought and did; a man of pure heart and blameless life; a faithful physician; a kind friend; a loving husband and father; a gentle companion; an exemplary citizen.

It is only at the hour of his death that many who knew Dr Morton well, will be conscious that a great man has been taken away, and a light quenched which has long shed a common lustre upon the country and the world.—(*The North American, Philadelphia.*)

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3. *M. De Savigny.*

The Paris Academy of Sciences has lately lost one of its members, M. De Savigny. We extract the following from a discourse pronounced at his funeral on the 14th of October, by M. Isidore Geoffroy Saint Hilaire :—

The illustrious member, to whom we have just rendered the last solemn duties, has long been missed from our meetings. Of those who surround his mortal remains, very few have had the happiness of personally knowing him ; and I am almost the only one to whom, during more than a quarter of a century, the melancholy privilege has been granted of witnessing the aggravated sufferings of his long-protracted disorder.

Marie-Jules-César Lelorgue de Savigny, was born on the 17th of April 1777 at Provins. He who was to be the subject of so many trials, was born under the most favourable auspices. His father was the son and the grandson of honourable magistrates ; his mother, who belonged to a rich and noble family of la Franche Comté, had illustrious and powerful connections ; and Savigny, whom nature as well as fortune had favoured, seemed to have in all respects the prospect of a happy and brilliant future. It was intended that he should enter into the Church ; and from his childhood the convent of Génovéfains became to him as a second home. He there spent a large proportion of his time, receiving from the most learned man then in Provins, Father Damoutier, instruction in History, Latin, Greek, and Hebrew, all of which were greedily received by the precocious intelligence of the youth. The Father Damoutier thought he saw in his pupil a future member of the French episcopate. These hopes and projects were vain ! The revolution broke out, and very soon Savigny at once lost all that he possessed. The career he had proposed to himself was definitely closed ; and his mother, who had now become a widow, could with difficulty save a paltry wreck of the family fortune. The old student of the Génovéfains now became the pupil of an apothecary in Provins. Under the guidance of his new master, Savigny made rapid progress in the study of natural history and of chemistry. A competition—*concours*—amongst the pupils of l'Ecole de Santé occurring at this time in the departments, Savigny, still young, presented himself, was one of the successful candidates, and came to Paris.

He was now, for the first time, separated from his mother; and in what circumstances were they next to meet? I dare not express all the fearful sufferings which, to my knowledge, they both experienced. Savigny at Paris, and his mother at Provins, felt all the horrors of the most extreme misery: they often suffered from cold, and more than once from want of food. And this without the consolation of corresponding, as they so earnestly desired to do. It was too much for a mother. Madame de Savigny was very soon conscious that her death was approaching. And how could she die without again seeing her son? She proceeded to Paris to the humble chamber of the student, the only asylum which it was in his power to offer her; and what an asylum! Who can tell the scenes of despair it witnessed? I shall give but one hint regarding this gloomy picture. One night, through the open roof, the snow fell upon the bed of the dying woman.

Savigny had not attained the age of twenty at the time of his mother's death; and even in his extreme old age, the recollection of these distressing times remained the most poignant in the midst of all his sufferings. It was always the most painful wound of that mind which was as tender as it was firm and energetic.

It was at this time that Savigny abandoned the study of medicine, in order to devote himself entirely to the natural sciences. Lamarck was his instructor. Under the auspices of this great master, Savigny, like Lamarck himself, became first a botanist; and when, somewhat later, Cuvier and M. Duméril procured his appointment as Professor of the Central School of the Seine-Inférieure, it was Vegetable Science which was assigned to him.

When setting out for Rouen, it was proposed to him to accompany General Bonaparte to the East. The only situation still vacant was that of a zoologist. "Accept it," *said Cuvier* (we quote his own words); "you will be a zoologist whenever you please." He accepted it, was associated with my father in the investigation of the invertebral animals, and set out with his friend for Egypt. The savants of Europe know how thoroughly he has justified the anticipations of Cuvier.

What Savigny did for science in Egypt and Syria, and what he has done since his return to France, we cannot here insist upon. Time would fail, and still more the equanimity which is required for giving an account of such labours.

We may, however, be permitted to signalize them in a twofold aspect. It is the rare glory of Savigny to have united, in a very great degree, the merits of the accurate, ingenious, and sagacious observer, to those of a generalizer who can be bold without ceasing to be exact. As a generalizer, who does not admire him demonstrating, in 1814, by the most delicate analysis, the analogous composition of the mouths of all the insect tribes, and thus creating in philosophical anatomy the first work, and certainly one of the most beautiful, which had been written beyond the families of the vertebrata! As an observer, in how many directions has he been the first to advance, and so far in this first effort, that subsequently it was difficult to make further progress!

Cuvier, in speaking of his researches concerning the Tunicata, does not say that he *discovers*, but that he *reveals;* for it is almost an unknown world into which he has introduced us: and of how many of his other labours might we speak in even more flattering terms. Savigny, along with Cuvier, undoubtedly is the principal originator of the movement which ever since more and more conducts zoologists to the study of the inferior animals, so long neglected, and yet now so fruitful.

All these admirable works, as well as many others, had occupied some years. What, then, might we not have expected from Savigny? He was, when admitted into the Academy in 1821, between a glorious past, and perhaps a still more glorious future. He was in the full vigour of life and of talent; he had immense works in preparation, and others already finished. But, alas! none of them were destined to be published, at least during his lifetime.

After several years of microscopic observation, he had been in 1817 for the first time attacked with *Tic Doloureux*, a nervous disorder of the senses, and especially of that of sight. When scarcely recovered, Savigny again betook himself to the researches from which he had lately suffered so much; and a second and more serious attack assailed him in 1824. This time his sufferings were to terminate only with his life. Savigny had foreseen this. Scarcely had the fatal symptoms reappeared, when he said, "I shall not recover: one cannot return twice from the grave." But who could have foreseen that his agony would be prolonged for twenty-seven years,—a terrible destiny, imprisoned in darkness.

Nor was this all;—when the darkness became less profound, when a gleam of light menaced the eyelids of the martyr of science, a shade, and two black veils, became necessary to protect him. And during these twenty-seven years, not a single day passed without suffering! Happily every day brought its own consolation! What would have become of our unfortunate brother, without one of these extraordinary instances of devotedness which God has implanted in the heart of Woman. In the dark retreat, near Versailles, where Savigny suffered for twenty-seven years, a female friend had imprisoned herself with him; and till the day of his deliverance she did not leave him, but was a voluntary captive for twenty-seven years, in solitude and darkness. We mention such acts, we do not praise them,—they are above all praise. And there are still other consolations which never fail to the most unfortunate,—those of hope. During the hours when his sufferings, though never interrupted, were less severe, and even in his last moments, Savigny looked back on his unpublished works, which had cost him so dear, and which he preserved without seeing, but without forgetting any part of them:—the hope that they would one day be restored to science, and that they would be published as a complementary volume to the great work on Egypt, has been his dying consolation.

Note on the Influence of a Tropical Climate on the Wool of the Sheep.

By JOHN DAVY, M.D., F.R.S. Lond. & Edin., &c. Communicated by the Author.

The sheep of Barbados, originally from an English stock, affords a striking example of the change that may be effected by climate, in a few generations, in the character of the hair of an animal. In that island instances are frequently to be seen of sheep, in which hair has so taken the place of wool (using the terms in their usual acceptation), that were it not for the form of the animals,—and that is not altogether free from change, —it would be impossible to suppose that they belonged to the same species as our English sheep.

Considering the subject of such a change not undeserving of attention, I have examined two specimens of hair procured for the purpose, one from a sheep two years old, the other from one about a year old, which were obligingly sent me, at my request, by a friend, a resident.

Both were nearly of the same colour, a light reddish-brown, and were nearly of the same length, that is, the individual hairs,—varying from about an inch to an inch-and-a-half. The hair of the three-year old was coarser than that of the one-year old; it consisted chiefly of harsh fibres slightly tortuous, each about 180th of an inch in diameter,—some cylindrical, others more or less flattened, all tapering towards a point at their distal extremity. The hair of the one-year old consisted of coarse and fine fibres in about equal portions; the one about 363d of an inch in diameter, the other about 1333d of an inch; the former resembling the hair of the older sheep, the latter having the appearance of wool, and that both in its fineness and general aspect, whether seen with the naked eye or under the microscope. The presence of a portion of wool mixed with the hair of the younger sheep, accords, I may remark, with the belief of my friend by whom the samples had been sent, viz., "that all the very young lambs of the island have wool, which gradually passes into hair as they grow older." This, he writes, he thinks is the fact, though he cannot say positively that it is so, not having attended sufficiently to the subject.

Interesting in itself, as exemplifying how Nature fits an animal, the native of a cool climate, by a change in its clothing, to endure without discomfort the heats of a tropical region, it is not, as it appears to me, without value in its analogical applications.

Though so much changed in appearance as is the wool in passing into hair, the one differs as little from the other in intimate structure as the hair of the woolly-headed African does from the straight, lank hair of the North American Indian, or as this does from the hair of the European. Examined under a high magnifying power, and with care, the differences in the qualities of all these kinds of hair, whether of the sheep or of man—colour apart—appear to be merely in degree. The wool of the sheep and its hair are both solid,—both exhibit the same transverse markings, the one strongly, the other feebly; and so of their other properties. The same may be said of the hair of the several varieties of the human race. And, keeping to the analogy, with which all experience is in accordance, we may confidently conclude, that provident Nature has not been less careful of man than of the brute, and that what is peculiar in the hair of each variety of the human race, as in the colour of the skin of each, is to be viewed rather as an excellence, connected with climate, and the effect of the adapting power of climate, than in any instance as a deformity or an unseemly defect.

LESKETH HOW, AMBLESIDE,
6th March 1852.

Upon Iodine in the Air, the Water, the Soil, and the Alimentary Products of the Alps of France and of Piedmont. By M. AD. CHATIN.

A. Arable soils do not furnish to water the same quantity of iodurets; and the variations that they exhibit, in this respect, generally correspond to those observed in the air and in soft waters. We may form an idea of these variations, by considering that whilst one or two grammes of soil, taken from the hills and terraces in the neighbourhood of Paris, or from the fields of Brie, of Beauce, of Bourbonnais, or of Bourgogne, suffice incontrovertibly to prove the presence of iodine, we must, generally, in order to obtain a corresponding result, operate upon double the weight of the soil of La Bresse or of the plain of Turin, and upon ten times the weight of the arable soil of Tarentaise, of Maurienne, and of the Valley of Aoste. It is a circumstance worthy of remark, that in the same district, reddish or ferruginous and clayey soils are more impregnated with iodine than white or bituminous and quartzose schist soils. I shall mention, as an example, the Valley of Graisivaudan, of which the yellow and rather stiff soil of the right bank resemble those of Bresse and the neighbourhood of Alexandria, while the black and light soil of the left bank are similar to those of the high valleys of Isere and of Arc.

The temperature of the water has a very great influence over its dissolving power of the compounds of iodine contained in the soil. Thus the schistous soil of the Alps, which does not yield an appreciable quantity of the iodurets to water of a temperature lower than +10 degrees centigrade, supplies a very sensible proportion at from +20 to 50 degrees centigrade. At 100 degrees centigrade, one pint (litre) of water can often extract from 10 grammes of this earth enough of iodine to bring it to the state of good drinkable water. The scarcity of the iodurets in the waters of the Alps, then, is explained, not solely by the state of the atmosphere, but also by the low temperature of the streams. It is highly probable that, previous to the greater part of the iodine which the pluvial waters yielded, the soil of the Alps had long furnished it; and possibly it may be the truth that the goitre and cretinism have only become endemic in those countries since this principle has become exhausted.

The presence of a certain proportion of carbonate of potash or of soda in water destined to extract the iodine from the soil renders them more soluble: this addition is also absolutely necessary for fixing iodine, when we operate at a high temperature. The action of alkalies particularly explains why all *alkaline mineral waters are iodurated.*

It is superfluous to remark that subjacent rocks, or such as are mixed with the arable soil in the midst of which their decomposition is going on, necessarily add more or less iodine in proportion to the quantity of it they themselves contain. Thus the millstone rock, in which iodine abounds,—the coarse limestone, where it is in a smaller proportion,—the plastic clay, where it is accumulated,—the middle and upper oolites, which often contain considerable quantities,—talc rocks, and clay-slates, where it is rare,—the limestones and saccharoidal dolomites, in which it does not exist,—evidently cannot yield an equal quantity to the soil.

In recapitulation, three circumstances, namely, its own nature, the subjacent rocks, and the quality and quantity of the rain-water, influence the richness of arable soil in iodurets.

Alimentary matters are differently iodurated, according to the soil which produces them. I have found less iodine in the maize of Aosta and Aiguebelle than in that of the plain of Alexandria; in the wines of Saint-Julien-en-Maurienne, and of Moutiers, than in those of Montmélian and of Asti, and especially in the wines of Burgundy, Orleans, and Bourdeaux; in the forage of the valleys of Arc, of Isere and of Doire-Baltée, than in those of the valleys of the Seine and the Loire; in the milk and cheese of Mont-Cenis, and of the farm of Cassines-Saint-Martin (near Aoste), than in the same products bought in the Paris market; in the corn of the right bank of the Valley of Graisivaudan, than in those of the opposite bank.

We now clearly perceive, why the atmosphere of the valleys of the Alps, which is little influenced by the general currents of the air, have not, moreover, an appreciable and peculiar ioduration. It is because the soil, yielding only very minute traces of iodurets in the waters which wash it, which waters, having fallen from an atmosphere nearly deprived of iodine, have in their turn almost none to bestow upon the soil.

B. There is a general *coincidence* between the amount *of iodine* in the air, the waters, the soil or alimentary products, and the complete absence of the goitre, and of cretinism,—between its progressive diminution and the corresponding development of these maladies. This coincidence results, not only from all the facts we have observed in the Alps, but also by separate observations made in the Pyrenees, the Soissonnais, the Brie, the Nièvre, the Meurthe, the Jura, the Vosges, upon the banks of the Rhine, and in Switzerland; it is confirmed by specific facts, especially by those which M. Boussingault has collected in the Cordilières of New Granada.*

The causes of goitre and of cretinism, are of two kinds:— 1*st*, A *special cause*, which is the *insufficiency of the quantity of iodine introduced into the animal economy;* 2*d*, *The general, or accessory causes*, amongst which may be reckoned, *damp and confined air, low, close, confined, and badly-situated dwellings, the want of light, the winds*, in as much as they are damp, and do not contain iodine, *the steepness of the mountains*, associated with the preceding circumstances, as nourishment deficient in reparatory principles, *filthy clothing*, interfering with the functions of the skin, *water deprived of oxygen*, but only as altered in its tonic qualities. I admit also the influence of *age*, that of the *sexes*, and of the *temperament*, proved by the relative frequency in the occurrence of goitre amongst fair women, that of its being *hereditary*, that of *occupations* and *habits*, which appears to result especially from the liability of persons who carry burdens on their head, to contract goitre.

In general, certain *mechanical influences*, and especially all *debilitating causes*, dispose to the formation of goitre, to which *tonic agents*, such as *dry air*, *wine*, *iron*, &c., give on the contrary the power of resistance to a certain extent; hence we are led to define goitre,—*A specific form of lymphatic disorder, determined by a special cause, the want of iodine.*

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* Professor Cantu, who is the first who has devoted himself to the general research regarding iodine, has correct ideas of the influence which this substance produces in the maintenance of health.

Thus, then, we may class the relations which exist between iodine, goitre, and cretinism, as follows:—

First zone, normal, that of Paris.—Goitre and cretinism are unknown. We find that, in this zone, on an average, the volume of air respired by man in twenty-four hours is from (7000 to 8000 pints, litres, according to M. Dumas): the quantity of water drunk, and of food consumed, during the same time, each include from $\frac{1}{100}$ to $\frac{1}{200}$ of a milligramme of iodine.

Second zone, that of Soissonnais.—Goitre is more or less rare, cretinism is unknown. It differs from the first zone only in the waters being hard, and being deprived of iodine.

Third zone, that of Lyons and Turin.—Goitre is more or less frequent, cretinism is almost unknown. The proportion of iodine has descended from $\frac{1}{500}$ to $\frac{1}{1000}$ of a milligramme.

Fourth zone, that of the Alpine valleys.—Goitre and cretinism are endemic. The proportion of iodine in the quantity of air, water, and food, consumed in a day, is at most $\frac{1}{2000}$ of a milligramme.

In the intermediate zones the goitre is subordinate to the general influences; in the fourth zone the deficiency of iodine preponderates.

We can do something to procure the iodine in the normal proportion: in the second zone by collecting the rain water; in the intermediate zones by the same waters, by making a choice of the springs, and by procuring food from those countries which are rich in iodine; in the fourth zone by the use of the preceding aliments, and of sulpho-iodine waters, after being deprived of sulphur, lavished by nature on the districts most afflicted with goitre, as well as by the use of iodurated salts, already advised by M. Boussingault and by M. Jules Grange. Animal and vegetable productions became iodurated by the use of saline waters, for drinking and in irrigations, as well as by the warm solutions procured by alkaline water from the most ferruginous soils and rocks.

On the Ethnography of Akkrah and Adampé, Gold Coast, Western Africa. By WILLIAM F. DANIELL, M.D., F.R.G.S., Assistant-Surgeon to the Forces, &c. Communicated by the Ethnological Society.

Among the aboriginal tribes that people the shores of Western Africa are several, which, from their geographical position, customs, diversity of language, and other national peculiarities, merit a more extensive research and consideration into their primitive origin than others. The veil of obscurity which, however, impends over the remote migrations and the distribution of the African races in general, rendered more impenetrable by the absence of any historic evidence or traditional data, constitutes a barrier that effectually precludes any minute inquiry into their progressive development and descent. In none, perhaps, of the scattered tribes, of which we possess a greater or less amount of knowledge connected with their more modern history, do these remarks more distinctly refer than to that community of negroes, which, peopling an eastern portion of the Gold Coast, have hitherto been comprehended under the ordinary designation of "The Akkrahs."

Some discrepancy of opinion formerly prevailed regarding the extent and limits of the territory to which their title could be strictly asserted; but, deferring all discussion upon this subject, it may be sufficient to state that the maritime belt of land at present occupied by the natives of Akkrah is of very circumscribed magnitude, since it only extends from the river Sakkoom, eastward to the small town of Tashia, a distance barely equal to fifteen miles. Inland its territorial boundaries are restricted within a much narrower compass. A brief allusion may be made to the various nations to whose close proximity this limitation can be ascribed, due allowance being granted for the provisional status which the events of a comparatively recent date have conferred upon them.

From the Sakkoom to the westward its confines are formed by the numerous Fanté provinces, united to which, on the north, are the two tributary kingdoms of Akim and Acquāpim, with the more distant Ashanté towns; while to the east and north-east, the Adampé, Aquambu, and Krépé races predominate, incorporated with other kindred tribes, which conjoined seaward with the Adampé settlements of Prampram, Ningo, and Adda, constitute not only a terminal barrier, but the connecting link that allies them to the great Popo populations more to leeward.

The aboriginal term employed to denote this insignificant tract of coast is *Ghán* or *Ghà*, a syllable extremely difficult to pronounce from its semiguttural intonation. By the Fanté and other Inta nations, it has been denominated *Inkran* or *Inkara*, a title that has possibly originated from the many termite hills that abound throughout the adjacent districts, and which in their language signifies an ant, although it might equally have been applied either in a just appreciation of its industrial resources and numerical inferiority, or as a derisive expression, to ridicule the moderate pretensions of its inhabitants. It may be satisfactory to remark that the name it now bears, and by which it has hitherto been known to Europeans from the earliest periods, has been derived from this source. The chief towns are three in number, viz., N'glish, Kinka, and Ossu; but the nomenclature under which they are more readily recognised, is that bestowed by the various European powers to whose authority they were amenable, and hence the distinctive appellations of English, Dutch, and Danish Akkrah. The largest in size, and the most ancient in date, is Kinka, or Dutch Akkrah, which, according to general tradition, was built long prior to the others, and on this account, therefore, not only assumes the precedency over the whole as the metropolis, but formerly exerted a certain amount of supremacy over those political or other native disputes which, from this exalted position, were exclusively referred to their arbitration and decision. The British fort situated in the first of these towns, lies seven miles to the eastward of the Rio Sakkoom, and has been placed by nautical writers in lat. 5° 31′ 53″ N., and long. 0° 11′ 30″ W.

The country in the immediate neighbourhood of these towns presents a pleasing and diversified aspect. Stretching far and wide a succession of long and verdant uplands gradually emerge from the coast, which, as they ascend inland, become broken into a variety of gentle undulations and continuous slopes, adorned by a woodland scenery extremely beautiful and picturesque. Advancing still deeper into the interior, these in turn partake of a more mingled character, and are ultimately blended with the elevated mounts and prominent highlands visible in the distance. In these localities the soil is exceedingly rich and fertile, the native plantations or farms producing, almost without the aid of human labour, that abundance of food which so bountifully supplies the necessities of all ranks of life.

In the lowland regions adjoining the ocean, the land is partially divested of those primeval forests and luxuriant underwood observed in other parts of the coast, and somewhat resembles one of those irregular prairies of Southern Africa, which, clothed with lank grass and a few flowers, are dotted at intervals by isolated thickets and occasional clump of trees.

Any dispassionate observer who has acquired but a superficial stock of information connected with the various inland kingdoms of this vast continent, cannot fail of discerning the abnormal changes and varying mutations which the moral and physical characteristics of their populations constantly undergo. Many which, from some peculiar combination of causes, have been more exposed than others to the afflicting concourse of wars, pestilences, and other depopulating calamities, in progress of time evince their decadence by a gradual decline or total loss of those inherent principles that constituted the basis of their power, while others, from the same controlling elements, become suddenly prostrated, and reduced almost to the verge of extinction. Retaining to the last their peculiar traces of difference, they succumb to the most warlike of their aggressors, until at length the predominant masses of their opponents so far absorb the scattered fragments, that all vestiges of their previous existence disappear. Thus, by such ceaseless and indirect agencies, nations after nations rise, flourish, and decay, and are eventually blotted out from the page of history. The races, however, inhabiting the sea-girt lowlands of Western Africa, have apparently suffered less from these systems of extirpation, when contrasted with others; for, located at a remote distance from the sphere of any internal convulsions, and enjoying but a moderate extent of frontier, with fewer adverse neighbours, they, of course, are less liable to the incidental operation of these causes. Although unable at first to stem the resistless influx of immigration, or the invasion of more potent tribes, which might partly subjugate and dispossess them of their territories, yet, the occurrence of these events at present, so far as can be ascertained, have seldom been of that permanent or effective duration as to entirely obliterate their nationality. Hence, we shall discover, dispersed in various localities, encompassed by the barriers of more populous kingdoms, the isolated vestiges of races, which, from dim and obscure sources, and through a succession of ages, have retained, in almost primitive integrity, their laws, usages, and institutions. Rational inferences, confirmed by the results of experience, have long since tended to point out the fact, that where the inhabitants of any petty country, from their close propinquity to some of the more powerful nations surrounding them, have maintained an intimate intercourse for any protracted period, they have become more or less tinctured with the prevalent customs and manners of the latter, either in consequence of their supposed utility, or from other views equally in unison with their social interests. But that these disjected communities should in general be enabled to resist the effects of such influential impressions, and after the lapse of centuries be capable of conserving, from the innovations of time and hostility of rivals, those essential peculiarities of structure and derivation, which sever them from others in their near vicinage, furnishes a remarkable subject for reflection, and must always excite deep interest and sympathy for those mysterious laws of humanity, that still exert, in unimpared energy, a silent, yet vital, authority over the future destiny and distribution of the negro races.

Making due allowance for the modifications which have necessarily occurred from events associated with European domination, and also from those that prominently figure as the sequence of certain controlling elements introduced into their moral and political codes, within the date of the last three centuries, these preliminary observations might be rendered applicable to the present status and condition of this remnant of a people who now claim our deep and merited consideration.

PART I.—MANNERS AND CUSTOMS.

Previously to the consideration of the moral and physical outlines of these people, and other historical subjects connected with their aboriginal development, it may perhaps be deemed more appropriate to enter into a brief descriptive detail of the various customs and institutions peculiar to these tribes, which may be conveniently arranged under the succeeding heads of—dress, cleanliness, births and nomenclature, marriages, deaths and funeral ceremonies, division of time, inheritances, and their laws, currency, architecture, and erection of towns, markets, and harvest, festivals, &c.

Dress, &c.—The dress of the natives does not materially deviate from that uniformity of style, which may be said to be characteristic of the cognate tribes of the Gold Coast, unless it is in some of those anomalous variations, that are to be observed among the females of certain localities, where they have probably been tolerated from politic or conscientious motives. That of the men is composed of two coverings, the first of which is an inner fold of cloth, tightly investing the loins and passing from between the nates forward, to the front of the pubes, where it is secured, after enclosing in a kind of suspensory bag, the organs of generation. The second consists of an external or proper garment, merely comprehending a few yards of chintz, tom coffee, or ramal, which, loosely wrapped round the middle, conceals the preceding one, its extremities being inversely folded within each other, or permitted to dangle from the arms, over which they are thrown on account of the greater length accorded to individuals of an elevated rank. On extraordinary occasions, and august festivals, silken and other costly fabrics usurp their place.

The costume of the women nearly resembles that of the opposite sex, only it is adjusted with more of elaborate neatness, and in that becoming mode which betokens some pretensions to taste. They also exhibit several distinctive peculiarities exclusively confined to their own and the Fanté community of nations, and not to be discovered in the other kingdoms of intertropical Africa. Encircling the waist, immediately above the hips, a cincture formed of two strings of large cylindrical beads known by the name of *Hennā*, is permanently worn by all classes, commonly in conjunction with a massive girdle of a smaller variety, partly coloured and of a globular figure (*Poumpon*). Mulatto females, the wives of caboceërs and other opulent personages, substitute in lieu of the latter a series of silver links or chains, to denote their higher degree of gentility. A third sort of bead not so frequently seen, but more worthy of attention from the antiquity of its origin, and the universal repute in which it was held long prior to the adoption of the articles in modern use, is the one termed *Fúfúah.* Constructed out of the smooth surfaces of bivalvular shells, in a circular form of attenuated dimensions, and with flattened sides that admit of their easy perforation through the centre, for the vegetable fibres on which they are densely strung, they furnish an interesting example of primitive art in connection with other instances of native ingenuity, that observation has recorded in these countries. They are now chiefly procured from the Adampé and Kreepé traders, who in days antecedent to those of European supervention, reaped a much more lucrative harvest than they do at present. They appear to be identical both in substance and design, with a similar species of ornament in common wear among the Boobies of Fernando Po, which however differ from them in their ruder manufacture and irregular circumference. Notwithstanding their depreciation in public esteem, they are still expressly valued for peculiar objects. Women after death, are seldom interred until bedecked with a zone of these shells, in order to ensure the recognition of their friends and ancestors in the next world, who are supposed not to be acquainted with the adjuncts of a later introduction.

A remarkable appendage which usually excites the surprise of he European on his first sojourn, is a protruding pad or cushion of ompressed cloth, placed posteriorly within the curvature of the loins, nd entitled in vulgar *parlance* a kankie, from its similarity towards ne in shape, but better understood by its local designation of *tuffo.* The purport of this strange appliance would seem to be ther problematical, from the inference produced by a confliction of ntiments on the subject. For some remark that it can only be ked in this position with the obvious intent of supporting the offspring carried by the mothers behind, after the prevalent habit, while others affirm that it is more with the view of facilitating a convenient arrangement of their dress. So far as the evidence is attainable, the popular interpretation is in favour of its appropriation to those significant purposes which render an analogous appendage essential to the contour of the fashionable dames in Europe. Its asmption was originally restricted to those who had attained the age puberty, but innovations of a licentious growth have greatly interd with this limitation. The custom, however, is more systematiy enforced in Prampram, Ningo, and the circumjacent territory, re girls habitually wander forth, in this scanty garb, the only one y are licensed to assume, until the expiration of their prescrip- probation. This garb is simply confined to a narrow strip of al passed beneath the pubes behind, and kept in its situation by above-mentioned cincture, which leaves both of its ends in pen-t *freedom.* To this circumstance is attributed the deductive term of *Attuffoy-yo*, by which they are distinguished. Previously to their assumption of a more matronly attire, they are obliged to submit to certain expurgatory rites instituted by the fetish, and as they receive the parting benediction of the priest, listen at the same time to the impressive admonitions he offers respecting the duties of a married life, into whose mysteries they are on the threshold of initiation.

Like those of the men, the garments of the females are divisible into an intermediate fold, and one or more outer coverings of the same materials but of better texture, which are retained in their position by the aid of a silk or cotton handkerchief bound round the middle. Both sexes are extremely partial to the use of the beads, and omit no opportunity of displaying them to advantage in the decoration of their persons. Every year witnesses fresh acquisitions to their private stock from the influx of novelties brought by the shipping, which alone, as mercantile imports, are eagerly coveted, and fetch a steady sale among the multitudinous tribes of the interior. They are distributed into bracelets and armlets that compass the wrist and upper arm, into circlets that inclose the ankle and leg below the knee, and into necklaces, in whose varied selection are blended all the hues of the rainbow. Another kind of necklace equally in vogue, is constructed from some testaceous product in an oblong or rhomboidal form, alternating with round black seeds, and is particularly patronised by the fetish men and their families, who, in these matters, arrogate to themselves the functions of conservators for all articles that are of aboriginal foundation. Hence they are deemed sacred, and bear the name of *Afflé* or *Afféle*.

Upon her marriage, the female, arrayed in the most attractive finery, and adorned with a variety of golden ornaments borrowed for the occasion, is paraded through various quarters of the town, accompanied by a troop of young friends and relatives, who chant in festive chorus the celebration of this auspicious event. On such occurrences, it is customary for the husband to be specially provided with gifts of connubial import, viz., metallic bracelet, a bunch of keys, and a symbolic device, all worked in silver, the last two being suspended on the girdle by the side of the bride. This device is denominated *Hennoné*, and comprehends on a diminutive scale, the representation of divers swords and dirks, with a shield, their usual war equipment, an elephant's tooth, and an ideal semblance of two cowries, one attached to each end, and the others depending from the central portion of a cylindrical bar or rod. It is not easy to ascertain whether this emblem was originally intended to convey a typical illustration of war and commerce, and the benefits that would result from the combination of both, or as a figurative intimation of the good fortune destined for the offspring to come forth, whether as opulent merchants, capable of disseminating their wares at thrice-told profits, or as renowned warriors, well qualified to wield the sword in defence of their country.

The dress of the Mulatto community is fashioned in accordance to the European mode, and is mostly made by native tailors, or transmitted from Europe at their own request. That of the women, on the contrary, partakes more of the country character, and with the exception of a cotton chemisette compactly fitted to the body and united down the front by stellate clasps of gold, there is no perceptible difference from those of the ordinary population, unless, indeed, it is in the finer quality and richer assortment of apparel and trinkets. At periods they occasionally conform to the style of the white ladies, but this, however, is less frequently than might be expected.

The manner in which the hair is trimmed, also furnishes another proof of an hereditary conservancy, though shared in common with many of the Inta races. It is drawn obliquely upwards into a conical mass, by the approximation of its extremities on the summit of the head, where they are tied together and inverted. It is arranged with methodical care and nicety, and when shaved or wholly cut off, is always indicative of affliction and misfortune, and thought to be one of the most degrading penalties that can befal any delinquent. Its denudation has evidently been viewed in a similar light by the Semitic nations, and has been alluded to in several of the Sacred Writings.* Generally, however, a silk or cotton kerchief is folded tightly round the head, and completely covers the greater part of it.

Cleanliness, &c.—In none of the regions of the coast are the precepts of cleanliness more strenuously advocated than by the population of Akkrah. The scarcity of fresh water, however, from the brief duration of the rainy season, and the absence of any contiguous stream or river, somewhat precludes their more regular observance on the part of the poorer inhabitants. To obviate, as far as possible, the inconveniences arising from these drawbacks, large ponds were scooped out on the outskirts of the town for the collection of the rain, and capacious tanks were built of solid masonry, and arched over under ground, for a similar object, within the precincts of the principal mansions, or hewn out of the rocks on which the European factories and forts were erected. By such contrivances a sufficient quantity was obtained to meet their domestic wants during the continuance of the dry months. They who were destitute of these resources were compelled to bring water either from country wells, or from a tributary branch of the Sakkoom, several miles distant. Morning and evening the women bathe themselves, either within their houses or in spots set apart for their convenience; while the men resort towards the close of the day to the afore-mentioned reservoir, or are reduced to the alternative of washing in sea-water, which, in fact, is the common practice among the labourers and slaves. *Sow*, a Fanté term for the dried ligneous fibres of some root prepared for these ablutions, is constantly used in conjunction with English or native soap, and, by its harsh friction, conduces greatly to soften and remove the excrementitious depositions on the skin. The cutaneous surface is subsequently anointed with palm oil, lard, or shea-butter, brought from the interior, and known by its familiar appellation of *Unku* or Ashanté grease, triturated with the fragrant powder of a bark called *Teufan*, and other aromatic perfumes, including those purchased from the merchants. Pomatum, chalk, limes, and other available accessories essential to the toilet of the native beauty, also lend their aid to increase the lustre of her charms, and towards the embellishment of her person, whose natural fascinations no efforts are spared to heighten. To secure the adulation of her lovers, and the supremacy over other rivals, is always the first consideration in African coteries, since it not only administers to the gratification of their self-esteem, but the amelioration or advancement of their existing condition.

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* *Vide* Job, i. 20; Deut. xxi. 13, &c.

Births.—The birth of any child, whether male or female, is not considered an event of such importance as to demand the institution of any religious or other rites. The offspring, like the Fanté and Mandingo tribes, receives its name on the eighth day, and a family custom is specially ordained for the purpose. On such occasions the infant is exhibited to its relatives and other connections which have congregated beneath the roof of the parents to offer their congratulations for its safe delivery, and to partake of the welcome hospitality of the house, which has been duly provided with rum and other intoxicating liquors, of which copious draughts are quaffed. On the other hand, each guest who attends the meeting usually contributes a few cowries towards defraying the expense of the ceremonial, while others, in addition, bestow a few articles of dress or some appropriate gift for the child itself. Thus, amidst a scene of homely festivity, it acquires its first dedication to humanity, and after this public acknowledgment of its rights of citizenship, is launched into the world within whose narrow vortex of toil and trouble it has to encounter the doom that inevitably attends upon all the chequered ordeals of life. Among the great and wealthy this custom is accompanied with protracted rejoicings and demonstrations of a careless liberality. In the selection of the name to be given they are mostly guided by certain ancient formulæ, which, having been faithfully adhered to by their progenitors, has descended to them as hereditary heirlooms from an almost primeval age. Identical with similar rites so commonly practised by the Inta races, they perhaps are coeval in date, and have collaterally descended from one radiating source, and, if not, the most probable explanation would be, that the Akkrahs procured them from the former, and engrafted such a portion upon their own social codes at some subsequent period, as would serve to supply any apparent deficiencies that might have then existed. Their titles are taken from the day of the week on which the infant is born, and are said to be mere modifications of the country terms by which they are known to the Fantés. Each day, therefore, has its own especial name attached to it, and in accordance with the sex of the progeny, whether male or female, is the derivation allotted. These distinctive appellations may thus be enumerated:—

Day.	*Male.*	*Female.*
Sunday	Quasshé	Akoshuah
Monday	Kudjo	Ajuah
Tuesday	Quanbbenah	Abranwah
Wednesday	Quakku	Akkuah
Thursday	Quahu	Abbah
Friday	Kuffië	Affeah
Saturday	Quahmé	Amah

To these also may be appended another series of names used in the Akkrah and Adampé towns, solely derived from the number of the offspring brought forth, and varied individually with reference to their sex. By this peculiar system of nomenclature, each child, as it may be boy or girl, occupies an allotted station conformable to its age on the scale of family precedence, fulfilling to a great extent the fundamental principles of primogeniture by the authoritative sanction of a title. The subjoined list includes the whole:—

Male.		*Female.*	
1 Tetté	7 Ashon	1 Deddā	7 Ashon
2 Tettā	8 Bontuwā	2 Kokkor	8 Bontuwā
3 Mensah	9 Akkron	3 Mansah	9 Akkron
4 Annah	10 Badù	4 Marnang	10 Badù
5 Annum	11 Oduko	5 Marnu	11 Oduko
6 ?	12 Odunyon	6 ?	12 Odunyon

As an illustration of the above, let us suppose that the accouchement of the woman should transpire on a Friday for example, either of her first or third son, as the case should happen, the designations they would then claim would be *Kuffië-tetté* and *Kuffië-mensah*; or if, under similar circumstances, she should give birth to daughters, they would become entitled to the respective cognomens of *Affeah-deddā* and *Affeah-mansah*. With the local authorities a wide diversity of opinion abounds, regarding the sixth place in the preceding numeration, the majority stating that, from some inexplicable cause, the vacancy which may at present be said to exist, has never been properly filled up, and that the words "*Shan* and *Shanshan*," which some aver *are* the legitimate terms, are not of native appliance but of foreign introduction, while their opponents argue stoutly to the contrary. To avoid the various arguments brought forward by both factions, I have provisionally omitted the "debateable points," and have placed them as they now stand, since the mass of evidence fully preponderates in favour of their non-retention. It is somewhat singular that the few primary names should so closely *correspond with* the Fulahné numerals Tettā (2), and Didde (3).

Females during the term of their gestation are accustomed to resort to some popular fetish-house, for the purpose of bathing in the consecrated waters vended by the priests, that by so doing, they may be enabled to crave for their unborn babes the guardianship of its unearthly divinity, and also to guarantee their safe delivery from the perils and disasters of parturition. After the happy fulfilment of this event, the parents, in grateful thanksgiving for the boon, bestow upon the infant a modified variation of that title by which the fetish has been generally denominated. From this source proceeds the third class or sacred appellations, a class to be found more or less prevalent throughout the kingdoms and districts where superstition and mystery hold their reign.

By the male populations of Akkrah and Adampé circumcision is constantly followed, but not at such an early age as by the Mohammedan nations more inland, the consummation being deferred until the boy has attained to the maturer growth of eight or ten years. This operation, comprehended under the native definition of *Kotéah*, is invariably performed by the country doctors, or rather exclusive practitioners of this surgical acquirement, who gather together in their houses as many tyros as is possible, the whole of whom, within a brief space of time, bear convincing proofs of their operative skill and dexterity. The season of the year deemed most propitious for the completion of these rites, is from the middle of December to the termination of January, when the dry Harmattan winds which then set in exert an almost specific influence towards the promotion of their successful cure. The process is very simple, the prepuce previous to its division being encircled by a ligature that protects the subjacent structures. The wound is afterwards dressed with raw cotton steeped in oil, and defended anteriorly by a grass or wicker-mat suspended by a cord round the neck of the invalid. With this shield also supported by both hands, they may be observed perambulating the streets with a timidity and awkwardness of gait that affords a marked contrast to their noisy yet cheerful vociferations. The doctor's fees, like the condition of his patients, is oftentimes humble, and rarely exceeds more than half-a-dozen strings of cowries.

Circumcision is one of the most prominent traits which establish the line of demarcation between the different tribes of the Gold Coast, distinguishing the blended races which, to the eastward, inhabit the long tract of shore equidistant on both sides of the river Volta, from the numerous nations that more exclusively trace their origin from the great Inta source, more inland and westerly. Neither the Ashantés, Akims, Fantés, Assins, Aquapims, Aquambus, nor many of the Kroo communities, still further westward, conform to the principle of its primitive induction, although isolated instances of its adoption have occasionally been recorded amongst *them.* The late Dr Pritchard has been led into an error when he *remarks that* it pertains *utriusque sexus* in Akkrah. During the period of my service at this station, repeated investigations into the currency and correctness of the report, has demonstrated that such a custom is unknown and unfollowed by the females. A popular usage of quite an opposite character is, however, inculcated by the Adampé women, living in the mountainous districts of Crobo, which apparently resembles the one so much in vogue at Whydah, and in the powerful kingdom of Dahomey, viz., *nymphæ elongatio artificialis.* The development of puberty in the girl is not promulgated by any public parade or ceremony, nor is a custom enjoined, yet such manifestations are frequently to be noticed in English and the other Akkrahs, but they will upon inquiry be found to proceed more decidedly from those Fanté inhabitants who have immigrated from the circumjacent countries, and located themselves within the town. Its institution has never been supported by the people of this part of the coast.

Marriages, &c.—Polygamy, as might be naturally expected, is carried on to an unbounded extent, the only restriction to the number of wives each man may possess being based on the resources he has of maintaining them. Many females are betrothed in their childhood to partners of a corresponding age, a bottle of rum and a fathom of cloth being annually paid by the parents of the latter, as a token of their sincerity and a continuous desire to confirm the conditional engagement previously entered into. When the parties have arrived at the proper state of maturity, the ratification of the contract is demanded, and, if no obstacle intervenes, the nuptial rite, if it can be so termed, is solemnised by a series of rejoicings which have been appropriately designated the "Marriage Custom." This social tie, however, is not connected with any religious formalities, and can only be viewed under the aspect of a purchase, since the woman, after the payment of the stipulated sum to her family, virtually becomes the property of her husband, who, invested with a legalised power, may allot her such duties or employment as he may deem fit. The dowry usually given to the family of the woman on these occasions amounts to the sum of two ounces of gold, or thirty-two dollars, two-thirds of which are uniformly set apart towards satisfying the domestic wants of the bride, being applied to the purchase of various articles of dress, household utensils, and other mercantile commodities. Detailed in the subjoined list is a variety of merchandise required for this object, which, as it was furnished by one of my own attendants on the solemnisation of his marriage, may be taken as a general estimate with reference to others.

6 Cloths of chintz, 4 yards each, .	$6	0
6 Heads of cowries, . . .	5	0
1 Brass pan for washing, . .	2	0
2 Fathoms of cloth for the mother, .	1	0
2 Fathoms of cloth for wife, .	1	0
1 *Comb* and pot of pomatum, .	1	0

6 Bottles of rum,	$0	60
Cowries for wife's box,	0	50
4 Silk Bandana handkerchiefs,	4	0
1 Girdle of small beads,	4	0
1 Wooden box,	1	0
1 Pint of lavender water,	1	0
1 Large stool,	2	0
1 Oil-pot, 1 looking-glass,	1	0
1 Silver bracelet,	0	50
1 Pot for Ashanté grease,	0	25

Twelve strings of cowries are also daily paid by the husband for the subsistence of his wife for the period of one week after the consummation of the marriage. Independently of the pecuniary outlay thus incurred, no inconsiderable source of expense is derived from the large consumption of rum and various edible conjuncts, in the convivial entertainments which are considered necessary for the due completion of the affair, inasmuch as the friends and connections of both parties willingly assemble to offer their congratulatious or to express their approbation of the match, if only for the purpose of indulging in the inordinate libations of rum and other intoxicating drinks which are lavishly provided on these festivals, especially if the husband is an influential chief or man of wealth.

Among the slaves and lower ranks of females, concubinage prevails to an indefinite extent, owing to the unfettered intercourse and licentious system in which both sexes are reared. From the vitiated code of morals thus germinated, no obstacles are opposed to the formation of these temporary unions with males of a corresponding grade, and, unfortunately, this plan is too commonly chosen by those who, from indolence, poverty, or other destitute conditions, are unable to provide the means to procure a wife after the more orthodox fashion. When the preliminary arrangements have been adjusted on both sides, a propitiatory gift is commonly presented to the woman to cement the alliance, which she exclusively reserves for her own use. It seldom exceeds the value of four dollars, and includes the following articles, viz.,

24 Strings of cowries.
4 Fathoms of cloth.
1 Silk handkerchief.
2 Bottles of rum.

A wide separation, however, is to be made between this mutual compact and the ordinary nuptial rite, perhaps more clearly defined by the extent of control exercised by the husband. In the former, the woman is less amenable to the jurisdiction of her partner, less subject to restraint, and may at any moment leave him with her progeny, upon the infliction of any act of injustice or cruelty; in the latter case the reverse precisely applies.

The women of Akkrah are not celebrated for their chastity, nor is it comprised among the category of those national virtues to which they conscientiously adhere, as its non-preservation constitutes no impediment to any permanent connection they may subsequently form. In the families of higher caste, indeed, it is somewhat different, but even with these exceptions, its due appreciation can only be referred to that judicious education and jealous vigilance bestowed by the parents during childhood. Should, however, the results of any illicit amour become palpable, abortion is secretly induced by the assistance of powerful emmenagogues indigenous to the country, or the offspring, by some connivance, is destroyed before it has attained any development, since its birth at the regular period would not only degrade the girl in the estimation of the public, but reflect such an indelible stain as would cling to her reputation for life. In these social communities, therefore, as might be inferred from the previous remarks, adultery is by no means of rare occurrence. The detection of these criminal liaisons is not punishable with death as in other kingdoms in the Bights of Benin and Biafra, but by the imposition of certain fines which are determined more by the rank of the offender than from any extenuating circumstances. The pecuniary compensations awarded in these verdicts are mostly in accordance with the legal usages of the place, and are founded on various distinctive grades which the parties occupy in their local position. Thus 12 dollars is the amount levied from an ordinary person, while a caboceer is mulcted in a much larger sum, viz., 32 dollars, and even more in many instances. These penalties are stringently exacted, so that it is not an unusual event for the poorer people to pawn one of their slaves or younger members of the family to raise the necessary sum in quittance of the fine. These derelictions from the marriage contract on the part of the female are sometimes visited by the sentence of severe corporal punishment, unless she has become notoriously addicted to such sensual pursuits, when she is, without farther warning summarily divorced. This ultimatum does not appear to be often had recourse to, inasmuch as the husband in the majority of cases cannot afford to lose the value of the services he had hitherto purchased; her family, under these peculiar conditions not being compelled to refund the marriage dowry, unless she refuses to remain with him; and the man is frequently too poor to obtain another wife.

Other curious ordinances are also retained by these people, among which may be embraced those regulating the intermarriages of different branches of the same family or tribe by particular degrees of affinity. These social restrictions, however, are limited within a narrow compass, and as it would seem, appertain more specially to the female offspring. Their hereditary predominance and extensive diffusion throughout several of the native races of Western Africa, point out the profundity of their origin and the durability of their sway, appreciable indications, so far, of their gradual descent from tribe to tribe, as they are indubitably coeval in date in their divergence from the great radiating sources of human migrations that have, after their primary severance and isolation from the parental stem, peopled the African continent.

With other proofs that may be adduced in support of these statements, may be mentioned the injunction which expressly forbids the union of any collateral issue by the woman's side. For example, the marriage of two sisters' children is never permitted to take place, on account of the intimate relationship reputed to exist between them, although it would readily be granted if one of the pair belonged to the brother's family. It must be borne in mind that this prohibition does not extend to those children proceeding from the brothers or male kindred, who are allowed to intermarry without the slightest prejudice, not only among themselves but with their cousins on the aunt's side. A man may not take two cousins to wife from the same parentage for equal valid objections, nor yet two sisters, which is agreeable to the strict enunciations of the Levitical* and Mohammedan laws, although polygamy prevails in the widest sense of freedom. Allusion has been made elsewhere to another mandate fully as imperative, but of more equivocal tendency, which, claiming its propagation from the earliest ages of the world, has been strenuously advocated even to this day by those Semitic races by whom it was principally adopted, viz., the marriage of a deceased person's wife by his brother or next successor. It is a notable fact that a modification of this custom was comprehended in the code of precepts given to the Jewish nation by their legislator, and interpolated by him, with others selected from the jurisprudence of the surrounding kingdoms, where it was probably designed to answer some important result. The passages in Holy Writ relative to these observances may be found in Deuteronomy, chapter xxv., and are as follow :—"If brethren dwell together, and one of them die, and have no child, the wife of the dead shall not marry without unto a stranger; her husband's brother shall go into her, and take her to him to wife, and perform the duty of a husband's brother unto her. And it shall be that the first-born which she beareth shall succeed in the name of his brother which is dead; that his name be not put out of Israel."

At Akkrah, and I believe in the other tribes along the Gold Coast, the elder rarely, if ever, inherits either the property or wives that pertained to his younger brothers or kinsmen upon their death; after this event they become engrafted on the estate of those next to them in consanguinity, and are thus successively transferred through the various ramifications of a family, as the seniors in turn respectively drop off. Under these circumstances, therefore, the eldest brother asserts no prerogative over them, since his appropriation of them would greatly militate against his dignity and prudence, by those who esteem him in the light of a father and protector to his brethren, and be also deemed derogatory to the position which he maintains, in descending so far below it as to unite himself with connections whose subordinate rank entitled them to rank little better than slaves.* It is well worthy of record how much these usages are in unison with those Divine injunctions conveyed in many passages of the Mosaic writings, and what conclusive evidence they furnish of their primeval derivation and remote history.

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* Leviticus, xviii. 18; Koran, chap. iv.

(*To be continued.*)

Professor Sedgwick's Classification and Nomenclature of the Older Palæozoic Rocks of Great Britain.

Professor Sedgwick, in a Memoir he lately read to the Geological Society, first discusses some questions suggested by his former paper, and states that he once considered the Coniston limestone, on fossil evidence, as the equivalent of the Caradoc sandstone, and the Coniston flagstone as the equivalent of the Wenlock shale; that he had afterwards (from a better knowledge of the Bala fossils, and a knowledge, also, that there were material errors in the sectional position of the lower groups of the Silurian System) for several years considered the Coniston and Bala limestone as exact or very nearly equivalents. Hence the importance of determining the place of the Coniston flags. He then concludes (on a review of all the new evidence and in accordance with fossil determination, both by Mr Salter and Professor M'Coy), that the Coniston flags are a true upper Bala group. Hence it seems to follow inevitably, that the Coniston grits are the equivalents of the Caradoc sandstone; to which conclusion, however, the fossil evidence is, at present, not contradictory, but almost entirely wanting. In the preceding view, the successive beds over the Coniston grits, up to the flags, grits, and tilestones of

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* We may come to the rational conclusion, from the tenor and close appliance of language used in the Koran, that the Prophet had unquestionably in contemplation the evil consequences which flow from the repeated intermarriages of kindred blood, said to cease only upon the extinction of the family name. To avert these dire contingencies, limitations were at length published, framed almost *verbatim* from those passages of Scriptural history that refer to the subject. These are enumerated in the fourth chapter of the Koran, and are as follow:—"Ye are forbidden to marry your mothers, and your daughters, and your sisters, and your aunts, both on the father's and on the mother's side, and your brother's daughters, and your sister's daughters, and your mothers who have given you suck, and your foster-sister, and your wives' mothers, and your daughters-in-law, which are under your tuition, born of your wives unto whom ye have gone into; and ye are also forbidden to take to wife two sisters, except what is already past."—*Sale's Translation.*

Kirkby Moor, must represent, in order, the whole Wenlock and Ludlow series. Hence, from the central granite of Skiddaw Forest to the highest tilestone near Kirby-Londsale, there is an ascending section on good parallelism with the whole ascending sections of Wales and the frontier Silurian country. He next compares the two great sections of Wales and Cumberland, &c., by help of two synoptical views, which are as follows :—

PALÆOZOIC ROCKS OF GREAT BRITAIN.

PRIMARY OR PALÆOZOIC SYSTEM.	Upper.	Permian series.		
		Carboniferous series.		
	Middle.	Devonian series.	Petherwin group.	Petherwin slate and Clymenia limestone. Mormand sandstone.
			Caithness group.	Hereford sandstone, marl, and cornstone. Dipterus flags.
			Plymouth group.	Dartmouth slate. Plymouth limestone and red grit. Liskeard slate.
	Lower.	Silurian Series.	Ludlow group.	Upper Ludlow. Aymestry limestone. Lower Ludlow.
			Wenlock group.	Wenlock limestone. Wenlock shale. Woolhope, or Lower Wenlock limestone and sandstone.
			Caradoc group.	Caradoc shale ? Caradoc sandstone and limestone.
		Cambrian series	Bala group.	Upper Bala (including Bala and Hirnant limestone, shales, flagstones, and conglomerates. Lower Bala.
			Festiniog group.	Arenaig slates and porphyry. Tremadoc slates. Lingula flags.
			Bangor group.	Harlech grits. Llanberris slates.

Metamorphic.

Granite.

PALÆOZOIC ROCKS OF CUMBRIA.

Carboniferous limestone.						
Old red sandstone.						
Silurian.		Flags and grits of Kirkby Moor.			=	Upper Ludlow.
		Coarse contorted slate and gritstone of Under Barrow.			=	Lower Ludlow.
		Ireleth slates.	Upper Ireleth slates.		=	Wenlock group.
			Lower Ireleth slates.	Calcareous slates. Dark slates.		
		Coniston grit.			=	Caradoc sandstone.
Cambrian.	(Upper Cambrian.)	Coniston flagstone. Coniston limestone.			=	Upper Bala.
	(Lower Cambrian.)	Greenslate and porphyry.			=	Lower Bala and Festiniog groups.
		Skiddaw slates.			=	Longmynd slates.
Matamorphic slates.						
Granite.						

By hypothetically placing the Longmynd slates on the parallel of the Skiddaw slates, the successive groups in the preceding tabular sections may readily be made to tally. In papers published during former years, Professor Sedgwick separated the Cambrian series into a lower and an upper division, which were called, respectively, Lower Cambrian Series and Upper Cambrian Series, and sometimes, after 1836, were called Lower Cambrian System and Upper Cambrian System; and he adopts the same subdivisions now, with, however, one change of demarcation, for he formerly made his line of separation at the Bala limestone, while he now makes it at the bottom of the lower Bala group of the tabular view. But he *never used the word System palæontologically*, but only to express a *definite sectional group* in a great series of deposits; and he contended many times against the adoption of the words "Silurian System" in any strict palæontological sense, as much as the "System" had neither a good physical nor palæontological base. It appeared to form a part, and a very small part, of the great Cambrian series. That these were his original views, and that he never changed them, he here proved by quotations from the "Proceedings" of the Society, and from other works. During nine or ten years he took for granted (on the unequivocal interpretation of the place of the lower Silurian rocks, as given by Sir R. I. Murchison), that the whole so-called Silurian System was properly determined in its position, and that it rested immediately on the abovementioned upper Cambrian division of the whole series. But difficulties arose in endeavouring, on this supposition, to join the upper Cambrian groups to the lower Silurian. A short historical account is given of these endeavours, which necessarily failed, not because the upper beds of the tabular section had been mistaken by the author, but because the base of the lower Silurian rocks had been misplaced, and their equivalents mistaken by the author of the Silurian System. The discussion of these questions led to the controversy (Quar. Jour. Geol. Soc., vol. iii., p. 167, 1847) which is here noticed; and the Professor remarks, that the whole argument of Sir R. I. Murchison is based on a general ideal section, which gives *his* conceptions of the relations of the Silurian System to the other rocks with which it comes in contact. This section he affirms to be not merely imperfect but erroneous in its assumed base, and also wrong in its interpretation of the second of its actual groups. Hence he affirms that the whole argument built upon it comes to the ground. And he further affirms, that in no part of the Silurian System have the true relations of the Llandeilo flags been made out, either to the beds above them or below them. They are unquestionably the equivalents of the calcareous slate of Bala, about the relations of which there never was any doubt. Hence he contends that the Llandeilo flags are an upper Cambrian, and not a lower Silurian, group; and that the *Caradoc* sandstone is the lowest group made out in a correct section by the author of the Silurian System. Hence, also, he contends that the collective names of the rocks in the tabular sections are correct, both on grounds of principle and of geographical propriety. The tabular section of Wales here given differs not at all from a general section exhibited by him in 1833.

On the Physical and Chemical Constitution of Natural Waters.

By M. E. Marchand.

From the researches which I have now for a long period made upon the physical and chemical constitution of natural waters, and their geological origin, the following conclusions may be drawn :—

1*st*, All natural waters, at least in the circumstances of which I shall presently speak, contain iodine and bromine.

2*d*, All these waters contain lithia.

3*d*, The whole of them, when they take their origin from superficial deposits connected with chalk, or in calcareous districts, contain iron.

4*th*, The origin of iodine and of bromine in water proceeds from the transportation of these principles from the water of the sea, from the vapours or the aqueous particles which incessantly escape from it, and which, transported to the continents, fall to the earth, in the state of rain, of snow, or of hail. The waters composing rain and snow generally contain an appreciable proportion of iodurets and of bromurets.

5*th*, In well-wooded countries, iodine and bromine may disappear from the water which holds them in solution, by passing to a saline state under the influence of vital forces, due to the number of mineral principles engendered by vegetation. The ashes of the greater part of our forest trees, elm, beech, fir, &c., contain iodine.

6*th*, The determinating causes of goitre and cretinism are not to be found in the existence of carbonate of magnesia in the waters which those afflicted with goitre and cretinism use for their necessary food.

7*th*, The determinating cause of these maladies exists rather in the absence of iodine and bromine from the number of constitutive principles of these waters.

8*th*, The physical and chemical constitution of water varies each day in the year, and, perhaps, even in every moment of the day. At the seasons when the temperature is highest, the density of the water is also strongest, and their richness in saline principles most considerable. A sudden variation in temperature produces also a considerable variation in the constitution of the water.

9th, We knew before this time the influence of the clearing of forests upon the abundance or the scarcity of springs. We had never, however, reckoned upon the influence of vegetation in general, and, particularly, of the influence of the cultivation of agricultural plants upon these same phenomena. It is generally believed that springs are more abundant in winter than in summer. This opinion is erroneous; it results, from my observations, that, in limestone formations at least, the springs are more abundant when vegetation is most active, and that they decrease in importance in proportion as vegetable life is extinguished. They are at their minimum of production about the 15th or 20th of January.

10*th,* All our water, of springs, of brooks, and of rivers, contain azotes; and, nevertheless, the water of the sea which receives these different fluids does not contain appreciable traces of these salts. This may be accounted for, on the one hand, from the influence of the respiration of fishes; the azotes contained in water, in passing with it through their gills, undergoes a decomposition of which the result is ammoniacal. On the other hand, in the depths of the ocean, a considerable quantity of univalve and bivalve mollusca are found (oysters, mussels, &c.), which continually excrete a certain quantity of free sulphuretted hydrogen, which, in its nascent state, ought still to convert to the ammoniacal state the nitric acid of the azotes with which it is in contact. The mud and slime deposited by the waters contain crystals of ammonico-magnesian phosphates, and the waters contain hydrosulphuric acid.

11*th,* Hydrosulphuric acid, free or combined, is also often, if not always, found in rain water. It is this principle which supplies with sulphur the plants belonging to the cruciferous family.

12*th,* From this last fact, it results that those localities which are infected by hydrosulphuric acid, may be purified therefrom by the cultivation of plants belonging to this family.

Sketch of the Climate and Vegetation of the Himalaya. By THOMAS THOMSON, M.D., Assistant Surgeon in the H.E.I.C. Service, Bengal Establishment.*

The great range of the Himalaya, when taken in conjunction with the still more elevated mountains behind, which are in nowise distinguishable from it, constitutes the most stupendous mass of mountains in the world, not only from containing the highest peaks, but also, and still more remarkably, as presenting by far the greatest area of elevated land.

This gigantic mountain mass lies to the north of the great plain of India, from which it rises on the whole very abruptly. It has a direction very nearly from east to west, its west extremity is, however, a little more northerly than the east, the latitude rising from 26° at the east, to 33° at the west extremity.

The mountain-chain to which the name of Himalaya is most properly applied, may be considered as bounded at the south by the plains of India, and on the north by the rivers Indus and Burrampooter, which have their sources in the same spot, and run one to the east, the other to the west, among lofty mountains, till they enter the Indian flat country. Nearly in the centre of this chain, in the most westerly part of Nepal Proper, lies the point of separation between the two great river systems, that of the Indus, and that of the Burrampooter, constituting a north and south axis, which, when better known, will probably prove to be the grand axis of Asia.

From this centre the chain of the Himalaya extends to nearly an equal distance in both directions, the central axis of the chain being the line of water-shed between the streams which run toward the plains of India on the south, and those which flow toward the Burrampooter and Indus on the north. This line of water-shed or central axis, will, on inspection of a map, be seen to be in general somewhat to the north of half-way between the two boundary lines of the chain, so that the distance from the axis to the plains of India, is greater than from the same place to the northern rivers. The mean width of the whole chain may be stated roughly to average about 150 miles, of which 90 are to the south of the line of water-shed, and 60 to the north of it.

From the central axis of the chain, lateral ranges of mountains run both to the north and south, stretching in the latter direction as far as the plains of India, and separated from one another by deep narrow valleys, which extend far into the interior of the mass of mountains.

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* *Vide* Proceedings of the Philosophical Society of Glasgow, 1851.

The number of lateral chains of the first class which form the line of division or water-shed between the basins of the great rivers on the south side of the central axis of the Himalaya, is about fourteen, separating from one another in a series from left to right the waters of the Jhelum, the Chenab, the Beas, the Ravi, the Sutlej, the Jumna, the Ganges, the Gogra, the Gandak, the Kosi, the Teesta, and the Subhansheri. These great chains, like the central axis, throw off lateral branches, which separate from one another the different branches, by the union of which within the mountains the great rivers are formed.

The elevation of the central axis of the Himalaya is probably at a mean about 18,000 or 20,000 feet; it is nearly uniform at about these elevations throughout a great part of the chain, but gradually diminishes toward both ends. Like all mountain-chains, it presents alternations of high and low portions, the lower parts, or passes, as they are called, from their affording the means of passage to travellers from one side or the other, being at the upper extremities of the river basins. These passes are, with a few exceptions, rarely under 17,000 or 18,000 feet. The lateral chains, starting from the more elevated portions of the central axis between the passes, gradually diminish in elevation as they approach the plains of India, not, however, with any exact uniformity of progression, for it is not unfrequent to find them rise into lofty peaks considerably more elevated than any known part of the central axis. The greater part of the giant peaks, which rise to an elevation of 26,000 or 28,000 feet, are situated in this manner, not on the central axis, but to the south of it; it is, however, by no means improbable that masses of equal elevation, not yet measured or observed, may occur behind them, it being unquestionable that the general elevation of the country continues to increase as we advance to the north, and that we have not yet (except in one place) attained to any point from which a descent is commenced towards the northern plains.

The direction of the principal lateral chains and of their included valleys, is, on the whole, perpendicular to the main axis, but with an inclination from the centre; those on the extreme east inclining to the eastward, while those on the extreme west have a very westerly direction. There are certain anomalies in the courses of the rivers, particularly at the north-west extremity of the chain; which, however, may be overlooked in a view so general and cursory of these rivers, as must necessarily be taken on the present occasion. The most marked of these peculiarities may be observed in the course of the Sutlej, which runs for a very considerable part of its course nearly parallel to the Indus before it turns toward the plains, thus separating the western part of the Himalayan chain, almost from its very origin, into two branches, one of which separates the Sutlej from the Indus; the other to the south of, and nearly parallel to, the other, divides the basin of the Sutlej from that of the Jumna and Ganges.

From the great depth of the valleys which separate the different mountain-chains, it but seldom happens that any road crosses from one valley to another; a traveller has therefore, in general, excellent opportunities of studying the direction and ramifications of the different chains, either in following the course of the valleys, or by travelling along the top of the ridges. In both cases he will find that his course is an undulating one, each chain and each branch of a chain being a curve, which bends first to one side and afterwards to the other, giving off generally a spur on the convex side, while the head of a valley insinuates itself into the concavity.

After these few words on the physical structure of the mountains, the vegetation of which it is my wish briefly to describe, it will still be necessary to devote a few minutes to the subject of climate and humidity, before I can proceed to my proper subject.

Situated in the most southern part of the temperate zone, and bounding on the north a great peninsula, which extends far into the torrid zone, the base of the Himalaya to the south possesses an almost tropical climate, tempered, however, when the sun is on the tropic of Capricorn by a moderately cool winter, and variously modified in different parts of the chain by the degree of humidity, a most important matter to be taken into consideration in every question connected with the phenomena of vegetable life.

The source of humidity in the Himalaya is almost entirely the Bay of Bengal, which is situated about 5 degrees to the south of the eastern extremity of the chain; and the wind which carries the humid atmosphere along the chain, is that which is known to nautical meteorologists as the south-west monsoon, a wind which begins to blow in the open sea about the month of April, but whose effects are not felt in the far interior before the month of June. This wind, though constant in its direction at sea, is not so in its inland course; at the head of the Bay of Bengal it is almost a south wind; it blows from the sea nearly due north towards the Himalaya, striking in its course upon the low chain of the Khasya hills, whose maximum elevation is scarcely 7000 feet.

Upon this range the first force of the monsoon is expended, and the annual fall of rain at Churra Poonjee, elevated 4000 feet on its southern slope, amounts to about 500 inches. This range, which has its origin among the mountain ranges of the south of China and north of Burmah, lies to the south of the Burrampooter, and following the course of that river, terminates in the concavity of its great bend, where it turns down toward the sea. The Khasya mountains do not, therefore, entirely run across the Bay of Bengal, so as to intercept the force of the monsoon from the whole of the Himalaya, a part of which wind, laden to saturation with moisture at a temperature of nearly 90° F., blows due north from the Bay of Bengal upon the district of Sikkim, which is on that account the most rainy part of the whole range of the Himalaya, for, on the one hand, the more eastern parts of the chain are protected by the Khasya range, and, on the other, the more westerly parts are more distant from the source of moisture, and, therefore, receive a less share of it. The interception of the moisture from the province of Bootan and the independent states north of Assam, by the Khasya range, has this curious effect, that the lower ranges of this portion of the Himalaya are dry and arid, while above 7000 feet, to which elevation only the hills to the south attain, the climate is much more humid.

The diminution in the amount of moisture in proceeding to the westward along the Himalaya from Sikkim is extremely gradual, but also so far as our at present rather limited number of observations goes, very regular. The effects of the south-west or rainy monsoon diminish step by step, as we advance westward, till on arriving at the valley of the Indus at the western extremity of the Himalaya, it ceases to be observed at all. In these most western portions of the chain, very little rain falls at any season of the year, and the little which does occur, falls in the spring months, and is, therefore, quite independent of the regular monsoon.

It is also worthy of note, that in the more western parts of the chain, the climate is extremely dry at all periods of the year, except during the monsoon or rainy season, as it is called in India, while to the eastward the climate of the mountains shares to a considerable extent the more equable and always moist climate of Bengal.

The most important point of all, however, regarding the climate in respect of its effects on vegetation which requires to be borne in mind, is that a very great portion of the rain which falls is deposited on the first range of mountains upon which the rain-wind strikes. I have already pointed out that this is the case with the Khasya range, and it is there strikingly illustrated by the fact, that it is only on the very south side of the hills that the rain-fall is so enormous, the fall twenty miles north of Churra being probably less than half what it is there.

This tendency of the rain-fall to exhaust itself very considerably on the first range of mountains to which it has access, is peculiarly important in a mountain chain 150 miles in width, its effect being that the upper part of all the large valleys, and especially the interior valleys and their ramifications, are much more dry than those adjacent to the plains of India. Even in the most humid part of the Himalaya, in Sikkim, this difference is extremely marked, and in the more dry parts to the west (the extreme east interior is not known), the inner valleys are so dry that rain is scarcely ever known to fall.

In close connection with the increase of aridity, as we advance from the plains of India to the interior of the mountains, I may mention the increased elevation of the line of perpetual congelation, which has evidently the same cause. In the outer lofty ranges of the Himalaya, the snow-line is met with at about 16,000 feet, while in the Tibetan part of the chain, many ridges of 20,000 feet of elevation are almost entirely bare of snow.

Having thus alluded, in very brief and general terms, to the most prominent physical features of the mountain chain of Himalaya, I shall proceed to describe, as rapidly as is consistent with clearness, the general character of the vegetation which is to be observed in its different parts at all elevations, from the plains of India to the uppermost limit of vegetable life. This would be an easy task if the vegetation were uniform throughout the whole chain, but owing to the great variations of climate to which I have just adverted, there is a very great difference in this respect, few, indeed, of the plants of the eastern extremity of the Himalaya being identical with those which occur in the far west. In general terms, it may be said, that to the eastward the vegetation is very much more luxuriant and tropical, and that it changes very gradually in advancing to the westward, in exact proportion to the diminution in the quantity of rain. The same gradual transition in the vegetable world may also be observed in advancing up the valleys, or in passing across the mountains from the outer valleys to those which are further removed from the Indian plain; though in the latter case, of course, the effects of gradually increasing elevation must be taken into consideration as partly the cause of the change as well as the decrease of humidity.

The plains of northern India which skirt the base of the Himalaya, do not (if we except the belt immediately at the base of the mountains) present by any means a rich flora. From their situation nearly on the tropics, their distance as a whole from the sea, and their proximity to the mountains, they are not very damp, and their climate has too decided a lowering of temperature in the cold season to permit them to be clothed with the dense forest vegetation which clothes the tropical plains of South America. They are in general open plains without much wood, and where not under cultivation, are covered either with a dense jungle of different species of arundo and saccharum, or with scattered trees of various tropical families, acaciæ and zizyphi being very common genera. Here and there only there are patches of forest generally low and scrubby, and without much underwood, or any of the fine parasitical plants and ferns which are so ornamental in tropical woods.

In the lower parts of Bengal, the proximity of the sea somewhat modifies this general character; a number of Ferns, one or two species of Pothos, and a few Orchideæ, among which *Vanda Roxburghii* and a large and fine Cymbidium are the most common, are to be found. In the same way the valleys of Silhet and Assam are exceptional in character, but from their being inclosed with mountains of some elevation on all sides, they are scarcely to be regarded as part of the Indian plain, but may more properly be considered as wide mountain valleys, and they in fact closely resemble in vegetation the valleys of the larger Himalayan rivers in the east part of the chain.

Close to the foot of the chain of mountains throughout its whole course from east to west, there lies a belt of forest and swampy land, which is well known in India by the name of Terai, and which, where it is developed to any considerable extent, bears a very bad character for unhealthiness, and is indeed in many places quite impassable for Europeans at most seasons of the year. This forest belt seems to be due to the greater humidity of atmosphere, and at the same time greater equability of temperature, which is produced by the proximity of the mountains. Its width is very various, from forty to fifty miles, to which I believe it attains in some parts of Nepal, to eight or ten miles, which is a more common width. Westward of the Jumna it almost disappears, being represented by a line of swampy or marshy ground, and a low jungle of bushes of the common plain species of trees.

In this belt, which occupies the base of the mountains, the vegetation is of course quite tropical in character, and is too varied to be described in detail. Large cotton trees (*Bombax*) are in all parts of it particularly conspicuous from the immense size of their trunks, which are not cylindrical, but buttressed all round by immense plates which project far forward from the main trunk. Numerous fig-trees of very various species are also common, especially to the eastward, where many fine forms of these magnificent trees everywhere meet the eye, along with species of *Dillenia*, *Careya*, *Bauhinia*, and *Lagerströmia*.

It is from the forest which lies along the foot of the Himalaya that a great part of the timber is derived which is consumed in northern India. In the most eastern part, the most valuable timber is furnished by *Lagerströmia regina*, and perhaps other allied species; further west, the *sâl Patica robusta*, the *Shorea robusta* of Roxburgh, is that which is most esteemed. The sâl extends from the valley of Assam as far west I believe as the Punjab, and is found not only in the forest tract, but also in hot valleys among the mountains. It belongs to a natural order (*Dipterocarpeæ*) which is peculiarly Indian, and which furnishes many valuable kinds of timber. None of the species, however, except the one under consideration, extend beyond the tropics; but they abound in the hilly countries of the peninsula as well as in the low ranges of the Malayan peninsula, and I believe in Java and other Indian islands. The sâl is so much valued that it has become, in accessible places from whence it can easily be conveyed to the plains, very scarce, and in the vicinity of large towns where there is a great demand for timber, I believe almost extinct. It is therefore less commonly employed than the *sissoo*, a species of *Dalbergia*, which is particularly abundant along the foot of the mountains, more especially to the westward, growing in great profusion on gravelly soil, and yielding a most ornamental and valuable wood.

The forest belt which skirts the base of the mountains rests for the most part upon a dry gravelly soil, which slopes somewhat rapidly, though not perceptibly to the eye, toward the open plains, and is generally dry. Just outside the forest, or sometimes still interspersed with patches of wooded ground, there is generally a low swampy tract, which is lower than the country immediately beyond, and from which the water drains away slowly and with difficulty. This is the Terai *par excellence*, and is, from the constant dampness of the soil, and the dense heat of the summer, peculiarly unhealthy. It is too low and too unhealthy to be much cultivated, and is generally covered by a dense jungle of tall grasses, species principally of *Saccharum*, *Arundo*, *Andropogon*, and *Anthistiria*, which rise high enough to cover an elephant, and afford shelter during the greater part of the year for multitudes of tigers and other wild animals; at the commencement of the cold weather, this long grass is set on fire and burnt down by the inhabitants of the hills, who at that season descend to the level country to feed their cattle and flocks. It is again abandoned to itself at the commencement of the hot season, as soon as grassy vegetation has made sufficient progress in the mountains. These swampy tracts are a series of lateral valleys which run parallel to the base of the mountains, and which, from being very slightly inclined, present great obstacles to the escape of the water discharged into them by numerous streams from the mountains.

Along many parts of the Himalaya, a similar series of valleys nearly parallel to the axis of the chain, but bounded externally by hills of from 2000 to 4000 feet in elevation, may be observed. These valleys are known in the western Himalaya by the name of Dhúns. One of the largest of them is the Deyra Dhún, well known to Indian travellers as being traversed *en route* to Masuri, a favourite hill station, and now celebrated as the seat of an extensive cultivation of tea in a climate which seems to suit admirably that valuable plant. The Deyra Dhún is in its centre or highest part, from which it slopes down both to east and west towards the Ganges and Jumna, about 2500 feet above the level of the sea, or 1500 feet above the level of the plains, immediately outside of its bounding range.

Other Dhúns occur all along the hills to the westward. They are bounded on the north by the ancient rocks of the Himalaya, but on their outer side always by the tertiary sandstones and conglomerates, now so well known from the labours of Falconer and Cautley, as the Sewalik formation. In the north of the Punjab there are often several series of these valleys, the innermost only resting on transition rocks, the others excavated out of the tertiary sandstones, which have there often a width of from 30 to 50 miles.

The vegetation of the low ranges of hills by which the Dhúns are bounded externally, does not deviate much, if at all, from the tropical type. They nowhere exceed an elevation of 4000 feet, which is not sufficient in isolated ridges to bring about a sufficient change of mean temperature to produce much alteration in the vegetation. They are only known I believe to the westward of Nepal, and therefore, in the drier parts of the region, they are generally covered with trees the same as those of the forest belt, with, in addition, a good deal of *Pinus longifolia*, a subtropical species of vine, and of a dwarf species of *Phœnix*, almost the only palm of the western Himalaya.

From these valleys where they exist, or from the open plains in other cases, the exterior ranges of the Himalaya generally rise abruptly to a height of 7000 or 8000 feet, in all parts of the chain, except at the point of exit of the great rivers, where of course the outline of the mountains is much modified. I shall probably better explain the structure of the mass of mountains, by saying that the lateral chain which separates any two adjacent river basins, generally terminates abruptly towards the plains in a bold promontory 7000 or 8000 feet in height, from which lateral branches parallel to the plains run in each direction, gradually diminishing in elevation till they are terminated by the great rivers. After the first sudden rise, the different ridges increase much more gradually, generally running nearly level for a number of miles, and then rising abruptly from 1000 to 2000 feet.

In ascending on the Himalaya (or indeed on any range of mountains) from the base to the line of perpetual snow, the change of vegetation is extremely gradual, and within a limited change of altitude barely perceptible, any division into groups must therefore be in a great measure arbitrary. Still some mode of subdivision is quite necessary for the purpose of description, as otherwise the mind would be puzzled by the multitude of facts. The less complicated, however, the mode of division is, the more intelligible it will be; it appears therefore quite sufficient to refer the forms of vegetation to three groups, similar to the three zones interposed between the equator and the pole, namely, tropical, temperate, and arctic; or to use the term more commonly applied in the case of mountains, *alpine* vegetation.

There is so great a diversity in the vegetation of different parts of the Himalaya, that I should entirely fail, were I to attempt to give any general idea of the vegetation of these different zones. I shall therefore select two particular spots, and by relating in some detail the gradual changes of the vegetation in each of these, I shall, I hope, be able to give a good general idea of the general appearance of the phenomena of vegetable life.

The hill station of Darjiling is distant from the plains of Bengal a little more than 36 miles; the road follows a ridge which ascends in the first 13 miles rapidly to about 7000 feet, and then runs gradually with little change of level for the remainder of the way. Throughout the whole distance the mountain sides are lined with dense forests; except in the early morning, an almost perpetual mist hangs over the trees, which collect and throw down from their foliage an abundant supply of moisture. On emerging from the dry belt of tropical forest, the ascent commences at once up a dry ridge, covered at first with the same species as grow upon the plain, species of Bombax, Terminalia; Sterculia, Emblica, Duabanga, Alstonia, Gmelina, Bauhinia and others are abundant, with many figs, some species of Artocarpus, and a proportion of bamboos. By degrees a vegetation characteristic of mountain tracts, but still tropical, takes the place of those just mentioned. A Gordonia is extremely abundant, with numerous euphorbiaceous trees allied to Mappa, various species of Garcinia, the toon (*Cedrela toona* or *serrata*), a variety of mimoseous trees, arboreous species of Vernonia and Helicia, beautiful Bauhiniæ both erect and scandent, the latter climbing to the tops of the highest trees with a trunk nearly as thick as a man. The road runs along the top, or on one side of the ridge, looking down into deep valleys full of the densest forest. If we leave the road to enter into these dark and moist hollows, we find that there are occasionally small tracts of flat land along the banks of the streams, which however, more frequently run through deep ravines, clothed with dense thickets of shade-loving trees, species of laurel, alder, magnolia, being mixed with the giant figs, which often form a great part of the forest. In these more shady places the plantain and tree fern luxuriate, and a dense brushwood covers the ground. Not unfrequently large tracts are covered with thickets of Calamus, a prickly palm which attaches itself, by long hooked flagelli to the trees, and often presents a formidable barrier to the traveller who tries to penetrate into its recesses. The trunks of the trees are often clothed with a dense mass of Pothos, and of the huge-leaved Scindapsus, completely encircling them all round, and converting them into leafy columns, while the wide-spreading branches of the higher trees bear a profusion of Orchideæ, which overspread them even to the very top, and, when in flower, have a most gorgeous effect.

In shady valleys, as low as 2000 feet, appear the first specimens of oaks and chestnuts, which in the equable temperature of such places, descend much further on the mountain slopes than in the more arid and variable climate of the western Himalaya.

On attaining an elevation of about 6000 feet, the vegetation has become temperate. The purely tropical forms have almost entirely disappeared, and in their place the forest abounds in trees of temperate climes. Species of Oak, Holly, Cherry, Laurel, Rhododendron, Styrax, and Magnolia, of gigantic size, form the forest, densely covered with mosses and orchideæ, and with an underwood of species of Berberis, Daphne, Lonicera, many species of Vitis, and smaller species of bamboo than those of the tropical region. Ferns are at such elevations extremely abundant.

From the station of Darjiling, the view in every direction overlooks mountain ranges, covered with dense forest, except in a few spots where partial clearances have been made for cultivation. No bare or grassy mountains meet the eye, no rocks or precipices afford any relief from the prevailing uniformity, which, but for the magnificence of the snowy mountains behind, would be undoubtedly monotonous and fatiguing.

The ascent from the plains of north-west India to Simla, is about the same length as that to Darjiling, but presents the most marked contrast in vegetation, being throughout bare and grassy. The road ascends at first in ten miles to an elevation of 6500 feet, then descends to about 1000 feet, and ascends gradually to 5000. The ascent commences from the Pinjore Dhùn, a lateral valley which runs at the foot of the mountains from the Sutlej to the Jumna rivers. There is no forest in this valley, which is open, and to a great extent cultivated. The lower hills are covered with a shrubby vegetation characteristic of a dry climate. Species of Zizyphus, Carissa, Butea, Adhatoda, Bergera, Ægle, Flacourtia, and other common shrubs, with one species of bamboo, and only one fig. After the ascent commences these bushes are only scattered at intervals over the hills, the greater part of the surface being bare and grassy. A similar open country extends all the way to Simla, except where a few fir trees (*Pinus longifolia*) crest the ridges, and in the more shady ravines, which are lined with a few small trees.

The transition from tropical to temperate vegetation begins, in so far as it is indicated by the small amount of shrubby vegetation, at about 5000 feet, but on the more exposed slopes, plants of warm climates extend up 1000 feet higher, and the herbaceous vegetation, principally grasses, is entirely composed of tropical forms.

It is only on approaching Simla, and attaining a height of nearly 7000 feet, that forest vegetation commences; at that elevation, open forests of Oak, Rhododendron, and Andromeda, intermixed with several species of pines, and a great number of temperate shrubs, of such genera as Rosa, Rubus, Viburnum, Berberis, Spiræa, Lonicera, Indigofera, Prinsepia, Salix, Daphne, and others.

The view from Simla presents a very marked contrast with that from Darjiling. The general outline of the mountains is very much the same, but they are more rocky, and very generally bare; the forests, which to the north are dense and abundant, occupying chiefly the north slopes of the mountains, so that in looking from the south the crest of the ridges only are seen to be wooded. The scenery, therefore, is more diversified than in the eastern Himalaya, and abstracting the snowy mountains, more pleasing to the eye.

Between the two extremes which I have described, every intermediate form may of course be met with, the law of alternation being apparently the following, that in advancing westward towards less *humid* climates, the lower hills from about 6000 to 2000 feet become more and more bare and grassy, while the lower levels and the base of the mountains retain a greater degree of damp and are clothed with forest. It would appear also that above 6000 or 7000 feet, up to 10,000 or 11,000 feet, at which elevation mountain ranges sensibly interrupt the passage of the moist atmosphere, the temperate ranges are more moist than those below them, which do not collect the clouds, and have a higher temperature, and consequently more powerful sun. To the eastward of Sikkim, the same phenomena are very well marked, the lower ranges being extremely dry and arid, while above 7000 feet, dense forest and a humid atmosphere prevail, just as in the mountains of Sikkim.

The valleys of the larger rivers which traverse the Himalaya from north to south, have of course a much lower elevation than the mountains by which they are surrounded; and up them, therefore, tropical vegetation penetrates very far into the interior. In the extreme west, the valleys of the Indus and Chenab, and even of the Sutlej, are up to the height of 5000 feet, which they do not attain till more than 100 miles from their exit into the plains, hot, dry, and tropical. Further east, the tropical forest stretches far up the valleys, and they are only bare for a small portion of their extent, and in the humid atmosphere of Sikkim they are densely wooded throughout. In that province, the valleys of the Teesta and its tributaries carry tropical vegetation far into the interior, almost within a day's journey of the line of perpetual snow, and the luxuriance of the dense and dripping forest requires to be seen to be understood.

The temperate region of the Himalaya may be said to extend from about 5000 feet, or a little above it, to the upper limit of arboreous vegetation; which, to the westward, is about 12,000 feet, to the east about 1000 feet higher. Above 9000 feet, however, the temperate region is characterised by many remarkable forms, which do not extend lower; these are generally, in the west especially, of very European type; but in the eastern flora, it is at such levels that the magnificent Rhododendrons of Sikkim, which form so striking a part of its flora, principally occur. In this zone a great part of the trees are of European genera, alder, oak, birch, hazel, hornbeam, horse-chestnut, and cherry, being characteristic forms. It is also especially the region of coniferous trees, very few of which extend either below or above it. The pine which descends to the lowest level in the Himalaya, is *Pinus longifolia*, which is a common tree throughout the whole region from the mountains of the Punjab to the east of Bootan. It is confined in a great measure to the outer ranges of the mountains, and commences as low as 1000 feet above the level of the sea, rarely if ever attaining a greater elevation than 7000 feet. This tree appears to have a very great power of enduring varieties of climate, for it seems equally at home in the hot, damp valleys of Sikkim, surrounded by an entirely tropical vegetation; and on the dry stony hills of the Punjab where rain hardly ever falls, and it is at all seasons exposed to a powerful and scorching sun. The only other coniferous tree of low elevations in the Himalaya is *Podocarpus*, one species of which is a native of the lower ranges of Nepal and Sikkim.

Pinus excelsa, which is allied to *P. Strobus*, and *Pinus Smithiana*, which is near *Abies*, are the more common species of the central zone, which are distributed throughout the whole extent of the Himalaya. In the same zone, the Deodar (*Cedrus deodara*) is confined to the western mountains, not being, I believe, to be found indigenous in any part of Nepal, while *P. Brunoniana*, on the other hand, commences in the eastern parts of Kamaon, and extends as far east as Bootan. The most alpine species of the family are *P. Gerardiana*, *P. Webbiana*, and several species of juniper, of which all but the first, which is a western tree, seem universally distributed.

It would be needless to dwell at any length on the alpine zone, because luxuriant as is the vegetation, and beautiful as are the plants, the forms at least must be familiar to most of my auditors.

I must be content, in conclusion, with drawing your attention to the change produced in the vegetation, in the temperate and subalpine zones as we advance towards the interior of the mountains, in consequence of the diminution in the amount of rain.

In travelling through the Himalaya we ascend a great river, the ascent is so very gradual, that the change of climate and of vegetation in ascending is almost imperceptible, and is only detected by careful observation. If, however, on the other hand, we cross a range of considerable elevation, and descend on its northern side into another valley, the transition is often very striking, and if the chain be sufficiently elevated to intercept the greater part of the rain, the contrast between its two sides is perfectly astonishing; when the transition is thus complete, the traveller leaves dense forests and common Himalayan vegetation on the one side, to find on the other a dry, barren, burnt-up soil, with scattered *Astragali*, *Boragineæ*, *Cruciferæ*, of forms quite characteristic of the flora of Siberia. Such is the vegetation of Tibet, which may be reached either suddenly by crossing a lofty pass, or gradually by ascending the Indus, the Chenab, the Sutlej, the Ganges, and many other of the Himalayan rivers. This arid vegetation is met on the Sutlej, as low as 10,000 feet above the level of the sea, and is therefore in no way dependent upon mere altitude.

Cosmological View.

Geological Society, Somerset House,
March 10, 1852.

Sir,—Mr Nasmyth having brought forward an hypothesis respecting the origin of light, which I have just met with in your last number, I am emboldened to mention an hypothesis on a kindred subject which occurred to me some months past.

Sir J. Herschel considers that the sun's outer *atmosphere* is the source of light to our system; and has, I believe, suggested that the sun himself, as well as the rest of the system, has been gradually condensed from a gaseous condition. Now, combining these two ideas, we may conceive of a period when, though both the sun and the earth were in nearly their present state of condensation, the luminous atmosphere of the sun was vastly more extended than it now is, and reached beyond the limits of our orbit. Under these conditions, the earth would receive a nearly uniform amount of external heat, and polar climates would not have begun to exist. We should thus be enabled to account for facts in geology which are more difficult of explanation than the glacial epoch,* namely, the occurrence of tropical forms of organic life in temperate and even in arctic latitudes, and the approach to a cosmopolitan distribution of species which we meet with in descending the geological series.

This hypothesis—for to no higher title does it aspire—will as well tally with the description in Gen. i. of the prior creation of light, as does that advanced by Mr Nasmyth, though both are open to the objection that *day* and *night* are mentioned before the creation of the sun. This, however, is a difficulty which has perhaps not been satisfactorily solved on any supposition.

In favour of the view which I am bringing forward, it may be observed that in Gen. i. 14 the Hebrew for "lights," is rather "luminaries or light-*bearers*."

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* See Hopkins on Changes of Climate, Geol. Quart. Journal, Feb. 1852.

Should you deem this communication worthy of a place in your journal, I shall consider myself honoured by its insertion. —I am, Sir, your obedient servant,

H. M. DE LA CONDAMINE.

PROF. JAMESON.

Eskimos, their Geographical Distribution.

The Eskimos are essentially a littoral people, and inhabit nearly five thousand miles of sea-board, from the Straits of Belleisle to the Peninsula of Alaska; not taking into the measurement the various indentations of the coast-line, nor including West and East Greenland, in which latter locality they make their nearest approach to the western coasts of the Old World. Throughout the great linear range here indicated, there is no material change in their language, nor any variation beyond what would be esteemed in England a mere provincialism. Albert, who was born on the East Main, or western shores of James' Bay, had no great difficulty in understanding and making himself understood by the Eskimos of the estuary of the Mackenzie, though by the nearest coast-line the distance between the two localities is at least two thousand five hundred miles. Traces of their encampments have been discovered as far north in the New World as Europeans have hitherto penetrated; and their capability of inhabiting these hyperborean regions is essentially owing to their consuming blubber for food and fuel, and their invention of the use of ice and snow as building materials. Though they employ drift-timber when it is available, they can do without it, and can supply its place in the formation of their weapons, sledges, and boat-frames, wholly by the teeth and bones of whales, morses, and other sea-animals. The habit of associating in numbers for the chase of the whale has sown among them the elements of civilization; and such of them as have been taken into the company's service at the fur-posts fall readily into the ways of their white associates, and are more industrious, handy, and intelligent, than the Indians. The few interpreters of the natives that I have been acquainted with (four in all), were strictly honest, and adhered rigidly to the truth; and I have every reason to believe, that within their own community the rights of property are held in great respect, even the hunting-grounds of families being kept sacred. Yet their covetousness of the property of strangers, and their dexterity in thieving, are remarkable, and they seem to have most of the vices, as well as the virtues, of the Norwegian Vikingr. Their personal bravery is conspicuous, and they are the only native nation on the North American continent who oppose their enemies face to face in open fight. Instead of flying, like the northern Indians, on the sight of a stranger, they did not scruple, in parties of two or three, to come off to our boats and enter into barter, and never on any occasion shewed the least disposition to yield any thing belonging to them through fear.—(*Sir John Richardson*).

Origin of the Eskimos.

The origin of the Eskimos has been much discussed, as being the pivot on which the inquiry into the original peopling of America has been made to turn. The question has been fairly and ably stated by Dr Latham, in his recent work "On the Varieties of Man," to which I must refer the reader; and I shall merely remark, that the Eskimos differ more in physical aspect from their nearest neighbours than the red races do from one another. Their lineaments have a decided resemblance to the Tartar or Chinese countenance. On the other hand, their language is admitted by philologists to be similar to the other North American tongues in its grammatical structure; so that, as Dr Latham has forcibly stated, the dissociation of the Eskimos from the neighbouring nations, on account of their physical dissimilarity, is met by an argument for their mutual affinity, deduced from philological coincidences.—(*Sir John Richardson.*)

On the Artificial Formation of Minerals. By HAUSMANN, EBELMEN, SANARMONT, and BECQUEREL.

1. *Artificial Formation of Minerals by Igneous Action.* By Professor HAUSMANN of Gottingen.

Mitscherlich, many years ago, published important details on this subject. More lately, Professor Hausmann of Gottingen, in an interesting Memoir, of which a copy was forwarded to us, gives an account of minerals he observed forming about furnaces, by furnace-action. He enumerates the following:—Silver, lead, copper, iron, bismuth, lead-glance, blende, oxide of zinc, red copper ore, iron-glance, magnetic iron ore, chrysolite, pyroxene, containing alumina, Humboldite, orthoclase, lead-vitriol, and arseniate of nickel.

Brown, yellow, green, and black blende were observed formed in the furnaces of the Lauten valley in the Hartz, in regular octahedrons and dodecahedrons; also, in lamellar and radiated concretions. Lead-glance, he informs us, is often formed by sublimations in the chimneys of furnaces, and the crystals are cubical with the usual cleavage; and crystals of magnetic iron sometimes incrust cavities in the stone or brick work of the furnaces.

2. *On the Artificial Formation of Minerals in the Dry Way, or through the agency of Heat.* By M. EBELMEN.

The method pursued by M. Ebelmen in his investigations, consists in dissolving the constituents of the mineral to be formed in an appropriate solvent, and submitting the whole to evaporation at a high temperature in a porcelain furnace. Boric acid was the solvent commonly employed, but the author also used borax, phosphoric acid, and certain alkaline phosphates and alkalies. Many minerals were formed by this method. Thus of the minerals belonging to the Spinel group several were obtained by the author. The experiments, however, have been repeated, and with better success, as regards the size and perfection of the crystals obtained.

Magnesian Spinel was prepared, by igniting a mixture of alumina, magnesia, chromate of potash, and boric acid, the mixture remaining in the furnace eight consecutive days. The crystals thus produced were octahedrons, truncated upon the twelve edges; some of them three or four millimetres in the side; they were transparent, of great lustre, and of a more or less marked rose colour. The angles measured perfectly corresponded to the theory; the density of the crystals was 3·542. *Gahnite* was obtained by a precisely similar process in well-defined, white, octahedral crystals, of density 4·58. By adding a small quantity of bichromate of potash to the mixture, *ruby-red* truncated octahedrons were obtained of great beauty and lustre. *Chromite of Manganese* was obtained by igniting together oxide of chromium, oxide of manganese, and boric acid. The crystals were regular octahedrons, of a semi-metallic iron-gray colour, of density 4·87, and of a hardness sufficient to scratch quartz. *Chromite of Zinc* was procured in the same manner, and obtained in the form of small, very brilliant, regular octahedrons of a greenish-black colour, and of density 5·309, at 11° C. The atomic volumes of the chromites were found somewhat higher than those of the aluminites, that of chromite of zinc being 27·5; of chromite of magnesia 28·7; of chromite of iron 28·3. *Ferrite of Zinc* was obtained in the form of small black brilliant octahedrons, of density 5·132. Its atomic volume is 29·3.

The formation and properties of artificial *Chrysoberyl*, the aluminate of glucina, were described by the author in a memoir, in the year 1847. By repeating the experiment, with the addition of carbonate of lime to the mixture of alumina, glucina, and boric acid, a perfectly pure Chrysoberyl was obtained in transparent crystals 5 or 6 millimetres in length. These crystals have a slightly greenish tint, are hard enough to scratch topaz, and of density 2·759 at 12° C. The crystalline form was found to correspond perfectly with the determinations of Descloizeaux, made with the natural mineral; many of the crystals were similar to those found in North America, in Brazil, and the Ural. *Chrysolite* or *Peridot* was obtained by fusing together silica, magnesia, and boric acid; the crystals were several millimetres in length, perfectly transparent, but slightly yellow; their form was an octahedron, with a rectangular base deeply truncated upon its two summits. The angles measured agreed perfectly with those of the mineral species. A borate of alumina, having the formula $(Al^2 O^2) BO^2$ was prepared by igniting alumina with borax, or by igniting alumina, oxide of cadmium, and boric acid. The crystals were rectangular prisms from six to ten millimetres in length, transparent and colourless, and hard enough to scratch quartz. The addition of silica to the mixture prevented the formation of a borate, and the alumina then crystallised in large hexagonal crystals of a very high lustre. These crystals are double six-sided pyramids, deeply truncated upon their two summits; the measured angles exactly corresponded with those of *Corundum*. The density of the crystals was found to be 3·928 at 20° C.; their hardness was that of Corundum, and they easily scratched topaz. In this process the silica may be replaced by other substances; carbonate of baryta gave large crystals of the same form; carbonate of soda produced the same effect, and several other bodies were employed without essentially modifying the result. *Rutile* was obtained in long acicular prisms by igniting a mixture of titanic acid with the phosphate of soda and ammonia; the crystals were transparent, and of a golden-yellow colour; their density was 4·283, which agrees with that of rutile. It will be remembered that

Daubrée obtained titanic acid crystallised by the action of the vapour of water upon the chloride of titanium at a high temperature; the crystals were however identical with *Brookite.*

3. *Experiments upon the Formation of Minerals in the Humid Way, in Metalliferous Repositories.* By M. DE SANARMONT.

Geology has means of investigation which are peculiar to itself, and now comprehends a certain number of especial truths definitively acquired to science.

It is thus that geology has been able, without foreign aid, to characterise the manner of the formation of the sedimentary rocks, and to arrange them in series; it is thus that it has succeeded in distinguishing in crystalline rocks, and in metalliferous repositories, different classes of which it can assign the probable origin; and in so far as it has not drawn conclusions too far removed from its fundamental principles, its anticipations have almost always been confirmed by experiment.

It is to mineralogical chemistry that geology owes the useful experimental control of its rational conceptions. Crystalline minerals have, in fact, a complete chemical origin; and it is chemical experiment which ought to support geology in its future progress in the study of the rocks of which it is composed.

Chemistry, then, can do much for geology by lending its means of experiment; but upon the condition of itself remaining purely geological; and of borrowing in its turn particular means of study, and the general data which the science *à priori* has collected upon all the conditional peculiarities of structure, relative position, association, or mutual exclusion, to which certain mineral species must needs be subject. In a word, it is necessary that all the circumstances where the natural operation has left characteristic traces, discovered by the geologist, should reappear in the artificial operation of the chemist.

The experiments, then, of mineralogical synthesis should embrace the different groups of mineral species which are united in nature, and should support themselves upon certain probable geological inductions concerning the formation of the beds which they enclose. Certain isolated species have already been obtained, and principally those which approximate to the usual products, according to the dry method. I have attempted to do more, and to discover some indices of the general causes which have originated the different classes of metalliferous beds.

I now commence this great problem, by the study of the concretionary veins which approach most nearly to the existing formations;

and the principles I have just explained have been the starting-point of the researches which I am about to submit to the Academy.

The concretionary repositories seem to be formed by solution; the mineral species which we there find would then be the products of the humid method, derived from liquid deposits, and to a certain extent may be compared to geysers and thermal springs. Moreover, the principles most generally prevalent, even at the present day, in these springs, are the carbonic and hydrosulphuric acids, the alkaline salts, and amongst others the carbonates and sulphurs; these, then, are the reagents which I have proposed first to employ. But amongst the different influences which may modify, in the subterranean canals, the usual chemical reactions, we must undoubtedly reckon first pressure and a temperature increasing indefinitely with the depth; and I have endeavoured to realise this double experimental condition.

It is very evident that this creates numerous difficulties; and we must not be surprised if the crystalline state of the products thus formed is sometimes imperfect, and always microscopic. Besides, it is not the size of the crystals which results from such problems, it is the mere fact of their creation; and in order to obtain more, all that is required, according to the expression of Daubenton, "is time, space, and rest,"—powerful means, which belong to nature alone.

The method which I have pursued essentially consists in producing all the chemical reactions *in a liquid condition*, and in glass tubes, hermetically sealed, heated from 100 to 350 degrees. I have almost solely employed solutions of carbonic and hydrosulphuric gases, of bicarbonates and alkaline sulphurs, alone or mixed in variable proportions; I have, then, I repeat, as for a starting-point the composition of many mineral waters, and their most energetic principles.

By these means of procedure I have artificially formed a great number of natural compounds. Each family of minerals generally group themselves around a common generating agent; so that we might then classify them thus in relation to the presumed composition of the thermal depositions which have served to produce them. I did not wish to make this approximation too absolutely; as it appears to me to go beyond the immediate interpretation of the facts; and I shall limit myself here to the mention of the compounds which I have obtained, and the different classes of minerals to which they belong.

Native Metals.—Copper and silver, mixed but not combined, as observed in certain mineral repositories in North America.

Native Arsenic.

Oxides.—Red iron ore $Fe^2 O^3$. Quartz $Si O^3$, in regular six-sided prisms, acuminated with six planes, with striæ, and sometimes with unequally-developed acuminating planes, so frequent in natural crystals. Red copper ore, or red oxide of copper, in red, shining, translucent octahedrons.

Carbonates.—Carbonate of magnesia. Carbonate of iron. Carbonate of manganese. Carbonate of cobalt. Carbonate of nickel. Carbonate of zinc. Malachite, or carbonate of copper.

Sulphates.—Sulphate of baryta, in the primitive form.

Sulphurets.—Realgar, in transparent crystals, with the colours, lustre, and form, as in mineral veins. Sulphuret of antimony, in acicular, shining, metallic-looking crystals. Sulphuret of bismuth, with similar characters as the preceding. Sulphuret of iron. Sulphuret of manganese. Sulphuret of cobalt. Sulphuret of nickel. Sulphuret of zinc. Sulphuret of copper. These last mentioned are massive, as is the case with those prepared in our laboratories; but it appears that the hydrosulphuric acid, under certain conditions of temperature and pressure, is a solvent of sulphurets, and a general agent of crystallisation. The properties of this acid explain the accumulation of metallic sulphurets in the deep parts of mineral repositories, and of metallic carbonates near their crop or outgoings.

Arseniosulphurets.—Mispikel in crystals, with the colour, lustre, and form of that found in mines. Red arsenical silver, having all the characters of the natural mineral.

Antimoniosulphurets.—Red antimonial silver, in large crystals.

Conclusions.

I had proposed to establish, upon experimental proofs, the controverted, and, as I think, very probable opinion, which attributes the filling up of the concretionary veins to incrusting thermal depositions, and to shew that the formation of a great number of minerals which we there meet, whether they be crystallised or amorphous, do not always presuppose conditions or agents far removed from the actual existing causes.

We thus, in fact, perceive that the two principal elements of the most widely-extended thermal springs, the sulphurets and the alkaline bicarbonates, have sufficed to produce twenty-nine distinct mineral species, almost all crystallised, belonging to the native metals, to the oxides, to the carbonates, to the sulphates, to the sulphurs, to the oxysulphurets, to the sulpho-arseniates, to the sulpho-antimoniates, in a word, to all the great families of the chemical compounds peculiar to concretionary beds, each of which has some representatives in my experiments.

Means of synthesis equally simple, applicable however to compounds as variable, give certainly a great probability to the speculative ideas which have directed me in these researches. It will, moreover, be necessary to diversify them to a much greater extent; and when we shall in the same manner have studied the different chemical agents, and the influences of every kind which can modify their effects, we shall undoubtedly succeed in defining the probable condition of the formation peculiar to each class of metalliferous beds: we might even hope, in thus tracing to their origin, step by step, in the same order of systematic experiments, we may finally arrive at the crystallised rocks which associate themselves to these beds by methods and phenomena of continuity which it is impossible to mistake.

4. *On the Artificial Formation, by the Humid Method, of Corundum and Diaspore.* By M. H. DE SANARMONT.

I have recently presented to the Academy experiments upon the artificial production, by the humid method, of many mineral species, under the influence of heat combined with strong pressure, and I have sought thus to explain the formation of a particular class of metalliferous deposits produced principally by liquid agents.

Other minerals belong to another class of repositories, wherein the influence of gaseous agents appears to have predominated, and where the water, which has been the chief agent in these phenomena must have operated principally in the state of vapour. We must not always expect to find between these two kinds of formation a clearly-defined line of demarcation. The substances which mineralise the thermal springs, perhaps arise from great depths beneath, under the form of volatile compounds, the liquid and gaseous agents may have combined in very variable proportions, and the phenomena must needs have exhibited themselves in many intermediate conditions between their two extreme limits. It is, besides, very difficult, even in a chemical point of view, to conceive a very different mode of action from water filling the same space in a liquid state at a very high temperature, and that saturating it in the state of vapour enormously compressed.

Many mineral compounds then will arise, almost indifferently in either of these circumstances, and I now desire to communicate the first results of those experiments which I have undertaken on this point, though they are still very incomplete.

If we heat very strongly a hydrochloric solution existing in an oxide under the formula of $R^2 O^3$, or $R O^2$, the acid even in excess becomes free in solution, and the oxide is separated. The complete precipitation, moreover, corresponds to a temperature which appears to depend upon the state of dilution, and the excess of the acid.

I have thus obtained anhydrous compounds, and sesquioxides of iron and of chrome, the titanic and stanic acids, pulverulent and amorphous, the latter only presenting some indications of crystallisation. Alumina, on the contrary, crystallises, in suitable circumstances, anhydrous in the state of *corundum*, and hydrated in the state of *diaspore*.

The *corundum* obtained by heating an acid solution procured from hydrochloric of alumina, at a temperature which must equal that of 350 degrees, is a white crystallised sand, which scratches the emerald when compressed between two polished plates. It is insoluble in acids, unalterable by heat, and under the microscope it shews that it is composed of very distinct rhomboidal crystals almost cubical, generally perfect, and more rarely modified by truncations on the angles, perfectly transparent, and acting regularly upon polarized light.

These rhomboidal crystals are often accompanied by other crystals in thin elongated plates. They are, like the *corundum*, insoluble in acids, but are decomposed when heated, and then the alumina is dissolved by sulphuric acid, a singular property, which M. Damcour has recognised in *diaspore*. In their normal state, they are transparent, act strongly upon polarized light, and their neutral lines are, the one parallel, the other perpendicular, at their greatest length.

It is worthy of remark, that the natural *diaspore*, almost always accompanies *corundum* in its various repositories, and this association is one of the geological proofs to which every attempt of artificial reproduction which endeavours to imitate the processes of nature should be subjected.

The oxides of iron, of chrome, of tin, and of titanium, are precipitated too rapidly to assume a regular structure. We can retard this separation, by rendering the liquid extremely acid, but then it very much corrodes glass. I am, then, obliged to defer these experiments until I have been able to procure tubes which will be more resisting than those generally furnished by commerce.

5. *On the Artificial Formation of Minerals by Electro-Chemical Action.* By M. Becquerel.

In ordinary chemical operations, when one body is made to act upon another, it is customary to powder them, to dissolve them, or to bring them into a state of igneous fusion. It is then almost impossible to observe the results of slow action, such as nature presents so often, and the electrical effects resulting from immediate contact, which may in certain cases aid in bringing about the former, or giving them a greater energy. Electro-chemistry, therefore, differs from chemistry in employing electricity as a subsidiary means of exciting affinity, or rendering it more efficacious, and in its requiring the mutual presence of three bodies, of which one at least must be in a solid state and another liquid. Such is the point of view under which I have constantly regarded electro-chemistry, which furnishes means of analysis and synthesis of which advantage might be taken. These researches have moreover the advantage of making known the necessary conditions under which solutions containing one or more combinations can react upon insoluble compounds with which they are in contract.

The weak actions which have particularly attracted my attention are those which commence as soon as the rocks, the metallic and other substances which occupy veins and beds, come in contact with the mineral waters which rise from all parts of the earth's interior. Time then becomes an element in the growth of the crystalline substances formed, an element which enters indefinitely into all natural phenomena, but which we can employ only within certain limits, sufficient, however, to obtain marked effects, as is shewn by the results obtained during the period which has elapsed since 1845.

Among the methods adopted in these experiments were the following:—

First Process.—This consisted in making a solution of silica or alumina in caustic potash or soda, react weakly upon a couple, formed of a plate of oxidisable metal, and a copper or platinum wire, round which the plate is bent, the whole being contained in a vessel closed by a cork, and left to spontaneous action.

In 1845 an apparatus was arranged, with a plate of amalgamated zinc surrounding a copper wire, and a solution of silica in potash, marking 22° on the areometer; water was decomposed, with evolution of hydrogen and formation of oxide of zinc, which dissolved. A fortnight afterwards very small regular octahedral crystals began to be perceptible on the zinc plate, the composition of which was represented by the formula ZnO, HO. The bulk of these crystals increased gradually, without passing a certain limit, about one millimetre, on each side.

In operating with alkaline solutions, more or less concentrated, it was observed that the crystals were larger and better defined when the strength was not beyond 20° or 25°. Other arrangements were made in 1845, by substituting for the zinc-copper couple a lead-copper one, and employing an alkaline solution of 25°; the lead was slowly attacked, the protoxide formed dissolving, and after saturation was deposited upon the surface of the plate of lead in anhydrous crystals. (PbO.)

These crystals, some of which measured several millimetres, were transparent, of a darkish green colour, and gave on trituration a yellowish powder. They were so grown together that only parts of their extremities were visible. Other reasons make it probable that the crystals are derivatives of a right rhombic prism.

Second Process.—Sulphuret of lead or galena (PbS) was made to act upon a saturated solution of sulphate of copper and of chloride of sodium, diluted with an equal volume of distilled water with a view of obtaining compounds of lead, having analogues in nature.

In May 1845 I made several arrangements of galena and the mixture of chloride of sodium and sulphate of copper, which were left to themselves until the present time. The following are the products which have been formed, either upon the pieces of galena, or the bottom or partitions of the vessels:—

1. Chloride of sodium in cubes, cubic octahedrons, and even octa-

hedrons having great transparency, very definite form, and from several millimetres to one centimetre in length.

2. Chloride of lead, in needles and cubes, slightly yellowish, of very perfect form.

3. Sulphate of lead, in cuneiform octahedrons, much modified, precisely resembling in form the crystallised sulphate of lead of Anglesea.

4. Chlorosulphate in needles.

5. Basic chloride, in microscopic crystals, disseminated here and there throughout the whole product.

6. Sulphuret of copper, black, without any appearance of crystallisation.

The whole of these substances covering the piece of galena gave it the appearance of a specimen from a mineral vein.

In some of the vessels there were formed only chloride and chlorosulphate of lead, in others chloride and sulphate, which depended no doubt upon the proportions of the sulphate of copper and of chloride of sodium, and the density of the solutions. A Voltaic couple, formed of a piece of galena, surrounded by a plantinum wire, placed in a saturated solution of common salt and sulphate of copper, diluted with three volumes of water, give rise to the formation of a considerable quantity of crystallised chloride of lead in cubes, without any other product; they were similarly deposited, though a little larger, upon a fragment of malachite which was placed in the solution.

There is no evidence in opposition to the opinion that these reactions take place in nature. In fact, the pluvial waters which reach the mineral masses and veins, formed of metallic combinations, become charged with chloride of sodium and sulphate of copper, arising from the decomposition of the cupreous pyrites; the resulting solutions, once in contact with the galena, react upon it weakly, and give rise to the various compounds described above.

Two other compounds have been obtained, $Pb\,O, CO^2$ and $Ca\,O, CO^2$, by the following processes:—Into a saturated solution of carbonate of soda and carbonate of copper was introduced a plate of lead, 4 centimes by 2, surrounded by a platinum wire, the whole placed in a glass vessel imperfectly closed, and left to spontaneous action for seven years. The lead gradually oxidised at the expense of the atmosphere; the oxide formed, slightly soluble in water, reacted upon the carbonate of copper, whence resulted hydrated oxide of copper and carbonate of lead ($Pb\,O, CO^2$). This was in very small crystals, covering the plate of lead, and their form appeared the same as the natural carbonate. The carbonate of lime was obtained by effecting the decomposition of the sulphate of that base, a salt slightly soluble in water, and naturally abundant, by a solution of bicarbonate of soda, a compound found in several mineral waters. A plate of Montmartre gypsum was introduced into the solution (saturated or not) of the latter salt; it soon lost its vitreous brilliancy, and was covered with small rhombohedrons of carbonate of lime. At the moment of contact, the gypsum dissolved, and reacted immediately upon the bicarbonate of soda. There was a separation of carbonic acid, which partly remained in the solution, on account of imperfect closeness of the vessel. The formation of sulphate of soda and carbonate of lime, in such a way that the plates which successively separated from the gypsum were formed of small attached rhombohedrons, cannot be supposed as solely owing to a double decomposition. It is probable that the dissolving action of the carbonic acid plays a part in the phenomenon. These effects always present themselves with weak solutions of bicarbonate.

These facts prove two principles, by the aid of which a certain number of insoluble crystalline compounds may be produced similar to the natural ones. The first consists in slowly oxidising a body in a solution of substances, upon which the oxide formed reacts, and whence result oxides and various crystallised insoluble compounds. The second relates to the feeble reactions which take place when a slightly soluble body is placed in contact with a solution containing several compounds, giving rise to double decomposition, in which case insoluble compounds are formed, which crystallise.—(*Comptes Rendus*, Feb. 1852; *Philosophical Magazine*, vol. iii., No. 17, 4th Series, p. 235.)

The Ocean.

"As we descend towards the present state of things, and lands and seas approximate to their existing relations, the geographic data become more certain. One side of the globe has, we find, its vanishing continent, the other its disappearing ocean. The northern portion of our own country presents almost the identical outline which the modern geographer transfers to his atlas, save that there is here and there a narrow selvage clipped off and given to the sea, and that while the loftier headlands protrude as far as now into the ocean, the friths and bays sweep further inland; but in the southern part of the island the map is greatly different; a broad channel sweeps outwards through the middle of the land; and the highlands of Wales, south and north, exist as a detached bold-featured island, placed half-way between the coasts of England and Ireland. I found it exceedingly pleasant to lie this day on the soft, short sward, and look down through the half-shut eye, as the clouds sailed slowly athwart the landscape, on an apparition of this departed sea, now in sunshine, now in shadow. Adventurous keel had never ploughed it, nor had human dwelling arisen on its shores; but I could see, amid its deep blue, as the light flashed out amain, the white gleam of wings around the dark tumbling of the whale and the grampus; and now, as the shadows rested on it dim and sombre, a huge shoal of ice-floes came drifting drearily from the north, the snow-laden rack brushing their fractured summits, and the stormy billows chafing angrily below.

"Was it the sound of the distant surf that was in mine ears or the low moan of the breeze, as it crept through the neighbouring wood? O, that hoarse voice of ocean, never silent since time first began, where has it not been uttered! There is stillness amid the calm of the arid rainless desert, where no spring rises and no streamlet flows, and the long caravan plies its weary march, amid the blinding glare of the sand, and the red unshaded rays of the fierce sun. But once and again, and yet again, has the roar of ocean been there. It is his sands that the winds heap up; and it is the skeleton remains of his vassals—shells and fish, and the stony coral—that the rocks underneath enclose. There is silence on the tall mountain peak, with its glittering mantle of snow, where the panting lungs labour to inhale the thin bleak air, where no insect murmurs, and no bird flies, and where the eye wanders over multitudinous hill-tops that lie far beneath, and vast dark forests that sweep on to the distant horizon, and along long hollow valleys, where the great rivers begin. And yet once and again, and yet again, has the roar of ocean been there. The effigies of his more ancient denizens we find sculptured on the crags, where they jut from beneath the ice into the mist wreath; and his later beaches, stage beyond stage, terrace the descending slopes. Where has the great destroyer not been, the devourer of continents, the blue foaming dragon, whose vocation it is to eat up the land? His ice-floes have alike furrowed the flat steppes of Siberia and the rocky flanks of Schehallion; and his nummulites and fish lie embedded in great stones of the pyramids, hewn in the times of the old Pharaohs, and in rocky folds of Lebanon still untouched by the tool. So long as ocean exists, there must be disintegration, dilapidation, change; and should the time ever arrive when the elevatory agencies, motionless and chill, shall sleep within their profound depths, to awaken no more, and should the sea still continue to impel its currents and to roll its waves, every continent and island would at length disappear, and again, as of old, 'when the fountains of the great deep were broken up,'

'A shoreless ocean tumble round the globe.'

"Was it with reference to this principle so recently recognised, that we are so expressly told in the Apocalypse respecting the renovated earth, in which the state of things shall be fixed and eternal, 'that there shall be no more sea?' or are we to regard the revelation as the mere hieroglyphic, the pictured shape, of some analogous moral truth? 'Reasoning from what we know,'—and what else remains to us? —an earth without a sea would be an earth without rain, without vegetation, without life, a dead and doleful planet of waste places, such as the telescope reveals to us in the moon. And yet the ocean does seem peculiarly a creature of time,—of all the great agents of vicissitude and change, the most influential and untiring; and to a state in which there shall be no vicissitude and no change,—in which the earthquakes shall not heave from beneath, nor the mountains wear down and the continents melt away—it seems inevitably necessary that there should be 'no more sea.'

"But, carried away by the speculation, I lag in my geological survey."

So writes a remarkable man, the eloquent HUGH MILLER, in his "*First Impressions of England and its People.*"

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1. *On the Structure of Ice.* 2. *Rapid Evaporation of Snow and Ice.* 3. *Dryness of Arctic Air.*

1. *Structure of Ice.*

With regard to the progress of the seasons, the "Indian summer," as it is called, brought us three weeks of fine weather after our arrival in September. The centre of Bear

Lake usually remains open till late in December, but by the middle of October the bays and straits are frozen across. As the structure of ice has of late years attracted the attention of speculative geologists, principally in connection with the movements of glaciers, I am induced to mention here a few facts which intruded themselves on my observation during my residences in the fur countries.

The first step in the freezing of rivers in this rigorous climate, after the water has been cooled down to 32° by a succession of cold weather, is the formation of somewhat circular plates of ice, six or eight inches in diameter. These drift for a time with the current, until they have become numerous enough to cover the surface of the water, when they are arrested in a narrow part of the river, or by any slight obstacle, and speedily adhere to each other, after which the interstices between the circles fill rapidly with crystals that bind all firmly together. The sheet of ice thus produced is at first nearly opaque; but when, in the course of a day or two, it has acquired the thickness of a few inches, it becomes transparent, and remains so until a fall of snow has obscured the surface. In unsheltered lakes the wind drifts the snow to the beach, and would perhaps keep the ice clean for great part of the winter, were it not that in certain hygrometric conditions of the atmosphere small starry tufts of most beautiful tabular and latticed crystals are deposited at short intervals on the ice, and freeze firmly to it. In a dry atmosphere, these crystals evaporate again, but should a fall take place of the fine dust-like snow, which is the most common kind in high latitudes, they serve to detain it until it consolidates, so as to resist the wind. It is rare, however, for the snow to lie more than a foot deep on any of the large lakes, unless where it has drifted under the lee of piled-up slabs of ice, or of rocks, islands, or other shelter.

During winter, the ice receives an increase of thickness from beneath, and at the same time evaporates above; the latter process going on with a rapidity that would scarcely be credible to one ignorant of the extreme dryness of the air in an arctic winter. The ice acquires a thickness of from 4 to 8 feet, according to the severity of the season, the depth of the lake, and other modifying circumstances; and I desire here to advert especially to the fact, that although it is constructed of successive horizontal additions beneath, when it decays in spring it consists of vertical prisms, penetrating its whole thickness, and standing side by side, like the columns of a basaltic cliff; which, in their mode of formation, have, I imagine, a close analogy. Dr Slagintweit informed me, that neither the ice nor the basalt forms exact prisms, the angles never having the precise measurements of true crystals. In this condition, the ice may be strong enough to support a considerable weight; and I have travelled over it with a large party on several occasions, when the prisms on which the foot rested were depressed at every step, and a pointed stick could be driven through the whole thickness into the water beneath, with as much ease as into a bank of snow. The ice then, in fact, presents the physical characters of a semifluid mass, as pointed out by Professor Forbes, its parts being moveable on each other, not only vertically, but, as in the case of travelling glaciers, capable of gliding past one another horizontally.

In spring, when the action of the sun-light is very powerful, an incipient thaw takes place at mid-day on the surface of the snow, which, on freezing again, acquires a glassy crust. As the season advances, but while the temperature of the air is still even at noon far below the freezing point, the crust in clear weather becomes penetrated in the direction in which it is struck by the sun's rays at mid-day by innumerable canals, and finally crumbles into a granular mass like the *firn* of the high Switz glaciers, that crackles under the feet as soon as the sun sinks towards the horizon. This firn is not universal; it is more common within the Arctic circle, and in situations where there seems to have been originally a certain looseness in the texture of the snow, and where its surface is so much inclined that the sun's rays do not fall on it obliquely about noon. I did not notice it in any quantity on the level surface of a lake.

2. *Rapid Evaporation of Snow and Ice.*

The rapid evaporation of snow and ice in the winter and spring, long before the action of the sun has produced the slightest thaw or appearance of moisture, is made evident to residents in the high latitudes by many facts of daily occurrence; and I may mention that the drying of linen furnishes a familiar one. When a shirt, after being washed, is exposed in the open air to a temperature of 40° or 50° below zero, it is instantly rigidly frozen, and may be broken if violently bent. If agitated when in this condition by a strong wind, it makes a rustling noise like theatrical thunder. In an hour or two, however, or nearly as quickly as it would do if exposed to the sun in the moist climate of England, it dries and becomes limber.

Mr Rae mentioned to me another example of the same fact, which bears on the transportation of boulders, and may interest geologists. During his memorable residence on the shores of Repulse Bay, he noticed several large boulders which were partially exposed at low water. When the sea froze they became engorged in the ice, and were lifted with it from the bottom by the flood-tides. The ice gaining at each tide in thickness beneath and losing above by superficial evaporation, the boulders in process of time came to rest in pits on its surface.

3. *Dryness of Arctic Air.*

In consequence of the extreme dryness of the atmosphere in winter, most articles of English manufacture made of wood, horn, or ivory, brought to Rupert's Land, are shrivelled, bent, and broken. The handles of razors and knives, combs, ivory scales, and various other things kept in the warm rooms, are damaged in this way. The human body also becomes visibly electric from the dryness of the skin. One cold night I rose from my bed, and, having lighted a lantern, I was going out to observe the thermometer, with no other clothing than my flannel night-dress, when, on approaching my hand to the iron latch of the door, a distinct spark was elicited. Friction of the skin at almost all times in winter produced the electric odour.—(*Journal of a Boat Voyage through Rupert's Land and the Arctic Sea. By Sir John Richardson.*)

Volcanoes in the Bay of Bengal, &c. By Dr Buist of Bombay. Communicated by the Author.

"One of the most terribly active groups of Volcanoes," says Mrs Somerville, begins with the Banda group of Islands, and extends through the Sunda group of Timor, Sumbaya, Balli, Java, and Sumatra, separated only by narrow channels, and altogether forming a gently-curved line 2000 miles long; but as the volcanic zone is continued through Barren Island and Neercondam in the Bay of Bengal (lat. 12° 15′), and northward along the entire coast of Arracan, the entire length of the volcanic range is a great deal more." * The band is not, as will be seen presently, limited to Arracan, but extends northward to Chittagong, lat. 22°, or 600 miles beyond Barren Island. The first description we possess of the volcano in question, is that of Lieut. Colebrook,† who visited it in 1787, when it was in a state of violent activity; he does not seem to have landed on it, and he quotes entire the account of it given by Captain Blair in his survey of the Andaman Islands. The cone, which springs from near the level of the sea, rising at an average of 32°, 17′, to 1800‡ feet nearly. Mr Lyell gives the following account of it; he does not quote his authority. "Barren Island, in the Bay of Bengal, is proposed as an illustration of the same phenomena (that of ancient craters of elevation, as contrasted with modern craters of eruption,) and here it is said we have the advantage of being able to contrast the ancient crater of elevation with the cone and crater of eruption, and its centre. When seen from the ocean, this island presents on almost all sides a surface of bare rocks, which rise up with a moderate declivity towards the interior: but at one point there is a narrow cleft, by which we can penetrate into the centre, and there discover that it is occupied by a great circular basin, filled by the waters of the sea, bounded all round by steep rocks, in the midst of which rises a volcanic cone, very frequently in eruption. The summit of this cone is 1690 French feet in height, corresponding to that of the circular border which encircles the basin, so that it can only be seen from the sea through the ravines." *

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* Physical Geography, vol. i., p. 257.

† Asiatic Researches, vol. iii., p. 396.

‡ Later authorities make 500 feet, and this is probably its true altitude.

Barren Island was visited by Dr John Adam in 1831. The water close in-shore was then hot and steamy, while steam and smoke issued from the crater, but no lava or flame. He estimates the diameter of the base at about 800 or 1000 yards, and the orifice of the crater, which occupies the entire summit of the cone, at about 30.† The latest description that has been published of Barren Island is that of Captain Miller, who visited it in 1843.‡ His account of it is the same in its general features as that of Lyell, but he estimates the altitude of the cone at no higher than 500 feet; and, considering the limited distance to which it is visible at sea, this seems to be more correct than the other estimates. He sets down the slope of the cone at 45, which would give an altitude of about 1000 feet, were Dr Adam correct as to the diamater of the base. Dr Adam states that it could only be ascended by climbing; and it is probable that Captain Blair's assumption of 32° 17′, as the acclivity which was determined by measurement, may be near the truth, and this would bring us back to Captain Miller's view of the altitude. The volcano, like the others along the bay, is chiefly active during the south-west monsoon.

Next to Barren Island is the volcanic Island of Narcandum, lat. 13° 22′. The cone is about 800 feet high; no soundings are to be had within half a mile of the shore.§ Crossing over to the other side of the bay, where perfect tranquillity seems for nearly a century to have reigned, we find a period when the Coromandel Coast was as much moved by volcanic agency as that of Arracan itself.

The earliest account we possess of any actual eruption in

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* Principles of Geology, 1830, vol. i., p. 390. This seems to be taken from Captain Blair's estimate of 1800 feet. It is upset, as already stated, by Captain Miller, Dr Adams, and others, who gave it at 500.

† Bengal Asiatic Transactions, 1832, vol. i.

‡ Calcutta Journal of Natural History, 1843, vol. iii.

§ *Report* of Calcutta Coal Committee, 1839.

the Bay of Bengal is that contained in the first volume of the Annual Register, 1776, reprinted in the Bengal Asiatic Transactions of 1847.[*] It was written by an officer on board a French East Indiaman, and addressed to his friend at the Hague: there seems no reason to question its perfect accuracy. In July 1757, fires were seen from Pondicherry to break out on the surface of the sea three or four leagues from shore; these blazed out with the greatest fury, throwing up pumice stone and combustible matter. This was accompanied by a noise like thunder, or the discharge of heavy ordnance. An island, a league in length and about the same in breadth, with a cone and crater in the centre, then appeared. A vast quantity of dead fish were afterwards seen floating on the surface of the water, destroyed by the eruption. The sea was some days afterwards so covered with pumice stone that vessels found it difficult to make their way through it, while they ran the risk of being burnt from the showers of hot ashes with which the air was darkened. The island seems speedily to have subsided again, as we hear no further mention made of it. A shoal called the Goris Bank, was seen by H.M.S. Melville, in a line joining Pondicherry[†] and Chittagong, and a shoal is noted on an old chart as having been met in with by an American ship in the line betwixt Pondicherry and Cheduba; both these have since then disappeared. Mr Piddington remarks that the middle of last century was the great epoch of earthquakes all over the world.

In 1750, Chili was visited by an earthquake, by which the town of Conception was destroyed; the sea rolled over it, and the entire port from thenceforth became useless. The whole shore seems to have sustained an upheaval of about 24 feet, and shells similar to those found in the adjoining seas are now abundant on mountains above 1000 feet high.* On the 15th September 1751, the capital of St Domingo was destroyed by an earthquake, and part of the coast, 20 leagues in length, sunk down, and has ever since formed a bay of the sea. The Lisbon earthquake, one of the most fearful on record, occurred in November 1755; and in 1757 the Azores were struck with an earthquake, during which eighteen small islands arose about 200 yards from the shore: these corresponded very closely with the Pondicherry explosion.†

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[*] Bengal Asiatic Transactions, 1847, vol. xvi., p. 499. Reports and Asiatic Researches, vol. i., p. 175. The papers of the Bengal Asiatic Society are indexed: the vast amount of most valuable information contained in the Reports can only be found by reading them through. This is the case with nearly the whole of that relating to volcanic phenomena.

[†] Abridged from the Remarks of Mr Piddington on the subject of the eruption. Bengal Asiatic Transactions, *ut sup.*

The volcanic region in the Bay of Bengal seems about this time to have been in a state of general activity. Off the coast of Arracan, lies an island called Cheduba, 15 miles in length, and 17 in breadth, or of about 200 square miles in area, situated in lat. 18° 50′ N., and long. 90° 40′ E. Its general appearance is that of a fertile, well-wooded island, of moderate height, and irregular outline. A band of level land, covered with fragments of coral, shells, and gravel, and but a little way elevated above the sea, surrounds it: three distinct terraces are visible, the result of so many separate upheavals.‡

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* Lyell's Principles, vol. i., p. 440, Ed. 1830.

† The following extract is from Dr Thomson's paper on the Geology of Bombay, Mad. Lit. Trans. It bears directly on the subject, and carries us three centuries further back; I have not considered the description specific enough for the text, but see no reason to doubt the authenticity of the facts. "The island of Vaypi, on the north side of Cochin (South Malabar coast), rose from out the sea in the year 1341; the date of its appearance is determined by its having given rise to a new era amongst the Hindoos, called Puduvepa, or the new introduction. Contemporaneously with the appearance of Vaypi, the waters, which, during the rainy season, were discharged from the Ghauts, broke through the banks of the channel which usually confined them, overwhelmed a village, and formed a lake and harbour so spacious that light ships could anchor where dry land formerly prevailed."—*Bartolomio's Voyage to the East Indies. Rome,* 1796. *Translation,* 1800.

‡ Captain B. Smith, in his admirable paper on Indian Earthquakes, published in 1842, Bl. As. Trans., vol. xii., gives an account from the "Gentleman's Magazine," of a violent earthquake which occurred at Calcutta in 1737. 20,000 vessels of various sizes are said to have been destroyed by the inundation which accompanied it, and 300,000 lives are said to have been lost on the occasion. No volcanic phenomena, strictly so-called, seem to have attended it. It took place during a furious hurricane. The earliest Indian earthquake of which particulars are given, is that which accompanied the hurricane of 26th

There are four large volcanoes in Cheduba, detached mounds, rather than cones, varying from 100 to 1000 feet above the level of the sea. They are composed of stiff gray clay, with large quantities of irregular fragments of stone; their sides are much cut up with rain, their summits, which are from 50 to 240 yards in diameter, are quite bare.* On the summits of these are numerous well-formed cones, from a few inches to 4 feet in height, and about the same in diameter. On the outside they are hard; within they are filled up with thick, uniform, well-mixed mud, which every now and then runs out at the side, or over the edge, of the crater, bubbles of gas rising at intervals of three or four minutes. There is no appearance of eruption of lava or scoriæ. Some of the volcanoes throw out hot water in place of mud; they are most active during the rains, and then occasionally emit flame and stones, as well as mud, throwing these to a considerable height; the stones are obviously torn from the beds through which the water passes; portions of copper occasionally adhered to them. Petroleum wells abound here as they do all round the neighbourhood. Captain Halsted visited Cheduba in 1841, and his survey in the *Childes* extended above 100 miles along the shore. The shore is marked by three well-defined terraces, or raised beaches, covered with coral and shells, and manifestly the result of three distinct upheavals, with considerable intervals,—of just a century, the natives believe,—betwixt them. The uppermost of these is less conspicuous and distinct than the two lower, but on the western coast a remarkable column of rock stands out on the beach, about 40 feet high, with oyster-shells still attaching to it, shewing the second line of beach, just 13 feet above the first. The last of these was said by an old

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May 1618, by which 2000 lives and 60 vessels are said to have been lost at Bombay. See Madr. Lit. Trans., 1837, already quoted from "Souza's Portuguese India," tome iii.

* Abridged from Captain Halsted's Report on the Island of Cheduba. Bl. As. Trans., 1841, vol. x., p. 434. Captain Halsted gives maps of the islands of Cheduba, and Regwan, adjoining to it. The latter is copied into Johnston's Physical Atlas, Map 3.

man of 106, who remembered it when he was a lad of 16, to have occurred about the year 1750.* Mr Piddington suggests that it is not unlikely that it may have occurred simultaneously with the eruption at Pondicherry in 1757,—natives being proverbially inaccurate as to dates,—during the general occurrence of violent earthquakes, when the sea washed several times over the lower part of the island, and then permanently retired as the land emerged. Captain B. Smith thinks it likely to have occurred during the Chittagong earthquake of 1762. Immense quantities of fish were found on the recovered land, and the feasting which occurred on these is still a favourite tradition in the island; no rent occurred in the earth, and no lives were lost or mischief occasioned; for more than half a century much of the soil remained salt. The elevation has been greatest towards the centre of the line examined, where it is 22 feet; at the termination it is 13; and at Foull Island 9. Regwan, lat. 18° 37′ 30,″ just to the north of Cheduba, is marked by three distinct risings,† each about 8 feet; the outer portion of the island was said to have been raised about 1760, most likely at the same time with the others. The original island contains two terraces, about 900 feet high; the outer margin is as yet barren, it consists generally of corals, shells, and gravel, the rest is a level plain of rice fields.

In the adjoining island of Ramree or Rumbree, off Kyouk Phyoo, there are some beautiful mud volcanoes, the cones of which are almost all covered with luxuriant casuarina trees, the only place where they are found in the neighbourhood. The craters and expelled matter possess the same general characteristics as those of Cheduba.‡ This was first described by Lieutenant Foley, in the 4th volume of the Asiatic

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* Mrs Somerville, Physical Geography, vol. i., p. 257, speaks of these as the result of gradual upheaval, going on within the last 100 years. It appears to have been the result of a sudden and instantaneous elevation, occurring just a century ago. There is no evidence of any subsequent change of level having occurred within this period along the shores of the Bay of Bengal.

† Note of Lieutenant M. Volloh, R.N., to map of Regwan, Bl. As. Trans. Johnston's Physical Atlas.

‡ Dr Spry, Bl. As. Trans., 1841, vol. x., p. 1848.

Journal. The cones are said by him to vary from 500 to 1500 feet, one peak, called Teeka, reaching the altitude of 3000. Vapour and flame were seen to issue from one of the peaks during the earthquake of 26th August 1833.

There are various hot springs at Chittagong subject to periodical eruptions, and which constantly emit gas and flame. In 1843 a cone appeared off False Island, but vanished in a few weeks, leaving no traces behind. About an hour after sunrise, on the 26th July, the inhabitants of Cheduba and Flat Island heard a great noise, and saw fire rising out of the sea; an earthquake had been felt just before. This continued for some days, when on the 29th a small island seemed to arise above the surface of the waters. It continued visible for about a month; but it was now the monsoon, and the weather was too boisterous to permit of its being approached. In October, on the return of the fine season, search was made for it, but no trace of it could be found. A careful survey of the spot was afterwards instituted by order of government, but no indication of commotion, and no change in the aspect of the shore or bottom of the sea was discoverable.*

There is a small volcano near Kyouk Phyoo in a constant state of activity, and which frequently emits smoke and flame. The country, at the distance of four miles from it, was, on the occasion of the eruption of 1842, brightly illuminated, yet so little was the heat that the specimens from the crater were nowhere melted.

Within little more than ten years of this, a catastrophe, precisely the opposite of that from which Cheduba suffered, overtook Chittagong. During the great earthquake of April 1762,† sixty square miles of the low lands along the shore were permanently submerged. Ces-lung-toom, one of the Mug mountains, entirely disappeared, and another sunk so low that its summit only remained visible.* Four hills are described as having been violently rent asunder, leaving open chasms, varying from 30 to 60 feet in width. Other mountains and hills were variously disturbed,—some were partially thrown down, so as partly to disturb the courses of rivers. One eminence became degraded by little and little, till it returned to the level of the plain. In the plain the earth opened in several places, throwing up mud and water of a sulphureous smell. At Barcharra 200 lives were lost on a track of ground that sunk suddenly. It is said that at Arracan the effects of the earthquake of 1762 were not less fatal to human life and property than those of the Lisbon one in 1755; while at Dacca the waters rose so suddenly as to throw all the boats on shore on its retirement, sweeping multitudes of human beings away. From the notices of islands on the western shore of the Bay of Bengal, now no longer to be found, in the accounts of Arab navigators, there can be no doubt whatever that numbers of these have been from time to time submerged.

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* Abridged from the report of Captain Russel of the H. C. S. Ganges, who was sent to examine the spot. The account of the eruption obtained from the inhabitants seems consistent and probable.

† As already stated, Captain B. Smith, considers these events to have occurred simultaneously, not, as stated above, at the interval of ten years. Mr Piddington assigning them the date of the Pondicherry rising, 1757.

On 2d January 1845, between the hours of six and seven P.M., about an hour after sunset, the people of Kyouk Phyoo, on the coast of Arracan, were astonished to see the eastern horizon to seaward become brightly illuminated; it continued flickering like the reflection of distant flame from a ship on fire for about half an hour, when suddenly immense volumes of flame were seen to burst, as if from the depths of the ocean, presenting the most sublime and awful spectacle to beholders. It was accompanied by a low continuous rumbling sound, which seemed to ascend from the bowels of the earth, and was re-echoed from the hills around. The duration of the exhibition is not mentioned, though it was seen by many witnesses; it seems to have been very transient. A vessel was sent out to sea immediately, under the impression of its being a conflagration, but saw nothing. Government, on being applied to by the Asiatic Society, instituted a careful survey of the coast, but no change in the depth of the soundings or character of the bottom could be discovered. There can, at the same time, remain no reasonable doubt that the exhibition was volcanic, probably a sudden emission of gas through an aperture or crevice not detected by the sounding-line.*

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* Phil. Transactions, Lond. 1763, given entire in Captain Smith's paper on earthquakes. Bl. Asiatic Transactions, vol. xii., p. 1047; quoted in Report of Coal Committee. To be seen in the India Review, 1839, p. 71. I have introduced the passage into the text nearly unaltered.

The region of recent direct volcanic action seems, so far as we at present know, to terminate with the lower extremity of the Delta of the Ganges; a few hot springs are all we have to indicate the agency of subterranean fire for nearly 1000 miles across the peninsula. There are hot springs in the Damoodah Valley, 23° 10′ N., in Gangetic India, in Kunowar, in the Lower Himalayas, and near Lohunkund, on the Sutlej. The most notable of these is that at Sargunga, near Chota Nagpore, in Central India, where the temperature of the water is 184°: it smells strongly, and seems to be a Harrowgate.† Dr Vosey describes a hot saline spring near Hydrabad, in the Deccan.‡ In the Concan there are no fewer than twelve hot springs betwixt Dasgaum and South Rajpore, and they are supposed to follow the line of the great Ghaut chain southward to Ceylon; the majority occur near the great lines of dislocation. There are two hot springs in Kandeish, and several in Kattiawar; and Lower Scinde, as we shall presently see, abounds with them.

Lake Loonar, on the Siehal Hills, is the only instance of a volcanic outburst observable in this immense plutonic region.§ It is a nearly-circular or oval depression, in a country composed entirely of tabular and nodular basalt. It is 500 feet in depth, and three or four miles in circumference. In the bottom of the hollow is a lake five feet deep, the waters of which are impregnated with muriate and sulphate of soda, and sulphate of lime. Subcarbonate of soda prevails in the neighbourhood. In 1851, it was examined by Dr Bradley who met in with abundance of scoriæ in the neighbourhood and was able to trace a vast stream of lava to the east and westward. The great intervals betwixt the points of volcanic activity in this part of India, even when connected by hot springs, prevents them from being associated as groups anywhere betwixt Arracan and Cutch.

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* Three accounts, by three different parties, differently situated, of this most singular occurrence, are given with great minuteness in the Reports of Proceedings of the Bengal Asiatic Society for February 1845, pp. xxiv., xxv., not indexed. The best account is that of Lieut. Hawkins.

† Col. Ouseley, Bl. As. Trans., vol. xvii., p. 1.

‡ Second Report on the Geology of Hydrabad.

§ Malcolmson, London Geological Transactions, 1839. It was first described by Lieut. Alexander, in the Madras Literary Transactions, subsequently by Mr Orlebar, in the Bombay Geographical Transactions.

On the 27th May 1846, a hill on the Nerbudda, called Dunnh Phai, or Smoking Mountain, about 500 feet high above the plain, gave out alarming moans, to the terror of the neighbourhood, and then an enormous outburst in it occurred. The appearance this presented, when examined shortly afterwards by Col. Skene and Lieut. Briggs, was such as might have been produced by the explosion of a mine, making a rent in the hill, from top to bottom, about thirty feet across and six feet deep. Great trees were upset by it, and the rocks rent twenty to thirty feet in pieces, as if blasted by gunpowder, and thrown to the opposite sides of the fissure. The appearance presented in no way resembled that of a land-slip,—the bursting force had obviously been from the interior. It was not stated that any erupted matter had been thrown out; there was no appearance of any volcanic swells in the neighbourhood, and no tradition of volcanoes ever having existed.*

In the end of October 1849, something like an ebullition of pestilential gas, the discharge probably of a submarine volcano, occurred off Porebunder, in Kattiawar, and was manifest for thirty or forty miles out at sea; the fish were poisoned by it, and for days lay floating in myriads on the surface of the water.†

There is no record of the Cutch volcanoes having ever been in a state of permanent activity, and they seem rather to have played the part of spiracles to the causes of earthquakes, when " the earth seemed, with a kind of colic, pinched and vexed," and fit of vomiting of lava or of flames. On the border of the chain of mountains, and eighteen miles from Luckput, the most westerly town in Cutch, is a hill believed by the Hindoos at one time to have been a volcano. It has long ceased to emit flames or smoke, but is still an object of worship among the Hindoos.* It does not appear to exhibit any variety of lava, scoriæ, or ashes. A bituminous earth, with a strong disagreeable odour, is dug out of the side of it, and used as incense in the worship of Assapoora. It is found in small pieces imbedded in the common soil, from which it is separated without difficulty.

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* Bengal Asiatic Transactions, vol. xvi. Reports.

† See Report of 1852 in Bengal Geographical Society.

On the occurrence of the great earthquake shock of June 1819, vast clouds of dust were seen to ascend from almost every hill on the range of hills in Goojerat and Cutch. Smoke was in many cases visible,† and some fire was perceived. At a place 26 miles west from Bhooj, fire was seen in considerable volume to burst forth, a blazing ball was projected into the air, and fell to the ground, where it was broken into four or five pieces, on which it became extinguished and invisible. No fragments could be discovered, but the vegetation was found scorched where it fell. On being examined next day, the hill was found rent and shattered, as if something within had sunk. Fire to a certain extent was said to have issued from a bituminous hill, from which alum is made, near Murr; the height of the hill was considered to have been reduced, and it was rent and shattered into ravines. Near the town of Sinderee, situated where a branch of the Indus joins the Runn, and which was permanently submerged on the occasion, a number of small cones, six or eight feet in height, burst up from the ground, and continued for many days to emit bubbles of air and mud from their summits.* The first and greatest shock occurred about seven P.M. on the 16th June, lesser shocks continued till the 20th, when the volcano called Denodur, about 30 miles northwest of Bhooj, burst into action, and the movements of the earth immediately stopped.†

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* M‘Murdo's Account of the Province of Cutch, Bombay Lit. Transactions, vol. ii., p. 210, quarto edition.

† Dr Thomson, in his Account of the Geology of Bombay, published in the Madras Literary Transactions for 1837, after describing the hurricane and earthquake which occurred all along the coast on the 15th and 16th May, (the 26th and 27th new style, exactly 200 years to a day before the occurrence of similar events in 1843) says, " Besides the appearance of a violent commotion in the atmosphere, and a perceptible concussion in the earth, volcanic action seems to have occurred, if we may be allowed to deduce such an inference from the highly-embellished representations of the historian, of giants seen in the air throwing great globes of fire at each other; confusion of human voices in the atmosphere, the trampling of horses, and the sound of warlike instruments." It is added that much of this nature occurred in Salsette and other places. (Souza's Portuguese India, tom. iii.) " The metaphorical figures," concludes Dr Thomson, " expressed in the latter part of the description, are strikingly similar to those employed by Dion Cassius, in his account of the eruption which destroyed Herculaneum and Pompeii, where we are told giants were seen, and the sounds of trumpets heard in the vicinity." There is so little appearance of any recent volcanic eruption near Bombay, that I should be disposed to ascribe the appearances, probably in both cases, to the meteorological phenomena always coincident with earthquakes and volcanic action.

Vestiges of recent outbursts, though of unknown date, appear at the village of Wagé-ke-Pudda. A high table-land of moveable matter about two miles square, has been blown out into a flat basin, the sides being broken into fissures, with craters, ravines, and hollows; and the interior or bed of the basin interspersed with hillocks and cones of every variety of colour, black, red, yellow, and white, and with patches of cinders similar to the refuse of a furnace; the whole looking as fresh as if the igneous agents were still in operation. The surface of the table-land immediately surrounding the blown-out space, is covered with burnt ironstone, similar to septaria, divided into irregular cells. On other parts of the table-land, craters of some 15 or 20 feet in depth have been blown out; they are composed of the materials just described, and are covered with patches of sulphur.‡

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* M'Murdo's account of the Earthquakes of Western India, 1819. Bombay Lit. Trans., vol. iii., p. 105.

† Captain Baird Smith on Indian Earthquakes. Bl. As. Trans., June 1843. The authority on which this statement is made is not stated.

‡ *Grant's* Geology of Cutch, London Trans., 1838, p. 316.

The rocks around the hot springs of Peer Mugger, ten miles east of Kurrachee, consist of nummulitic limestone, in some cases highly crystallised, and where the fossils, according to Captain Ficary, occasionally are entirely altered. Two miles further to the westward, occurs the group of Minora Hills, about 800 feet above the sea, and 500 above the plain around. On the eastern side a crater has been blown out; the ruins are scattered around. It is oval in form, about 150 feet in length, and 50 across. The explosion has burst away one of the sides, and blown through the strata adjoining. It seems as if a vast deluge of water had for a short time been discharged from it. There is no tradition* in existence regarding it, nor is anything known of the date when it was last in commotion. It has clearly been subject to the great changes which have taken place around, and it is probable it preceded the deposit of post-pleocene clays found at its base,† as these bear no appearance of disturbance, and have most likely been deposited by the sea, subsequent to the explosion. There are several other craters of lesser size, and more imperfect structure round Minora. The rocks at the Lukkee Pass hot springs appear to be of exactly the same description as those at Peer Muggun—their position in all likelihood due to volcanic influence of comparatively recent existence. The hot springs of Peer Muggun attain a temperature of from 100 to 150, and yield a very copious discharge—the water is perfectly pure, and fertilizes the soil around.* One of the tanks contains nearly 200 crocodiles. There is a spring at no great distance which affords large deposits of sea salt.

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* Captain Carless, who gives (1838) by far the best account of this district yet published, speaks of "a celebrated hill called Jibel Pubb, 20 miles north-west of the hot springs, of which wonderful stories are related all over the country;" but he does not tell us what these stories are. Bombay Geographical Transactions.

† Captain Ficary describes the clays as post-pleocene. He makes no mention of the crater. I visited it, and took careful drawings and measurements of it in March 1850. The highly-crystalline state of the rock is conspicuous. I confess I could discover no evidence of any diminution of its fossils around the springs or near the crater. The rocks which every where around are one mass of shell and zoophytes, the corals being often in the most beautifully perfect state that can be imagined, have been in some places highly crystallised, the organic remains being in part obliterated. The crystals are occasionally arranged in beautiful star-like forms, like many members of the zoolite family.

The next volcanic group to be met with in this direction is that of Hinglay, a series of mud volcanoes very similar in point of form to those of Cheduba, along the sea-board of Lus, and now in great activity. Here there is no appearance whatever of there ever having been any eruption of lava. The first of these are called the Koops of Chimdra; they are believed to be of Divine origin, and to be possessed of miraculous virtues.

The extent of this volcanic field has never been precisely determined; it extends some fifty or sixty miles inward, and at least three times as much along-shore.

The band, if band it be, now trends away southerly from lat. 22° to lat. 12°; and next group we meet in with is that at the mouth and lower part of the Red Sea, commencing with Cape Aden,† and concluding with Gibbel Teir, extending across from the former of these to the Salt Lake Assal, inland from Tadjoura—so inland for 100 miles.

Aden is spoken of by Arab writers as having been in a state of activity within the historic period; and though there scarcely seems evidence sufficient of this to be relied on, and a considerable presumption to the contrary, it has all the appearance of great recency.

(*To be concluded in our next Number.*)

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* The hot spring takes its name from Peer Muggun, a Mohammedan saint whose shrine is close by. The coincidence of the sound with the designation given to the long-snouted crocodile (muggun) had led to the inference that it was Peer Muggun, the Crocodile saint. The crocodiles in the tank are of the kind called Gavial—they are precisely similar to those of the Nile and Ganges—not at all like the muggun.

† See Dr Bird's Notes to Captain Foster's Account of Cape Aden, Bombay Geographical Transactions. Referred to in Report of the Society for 1850, vol. ix.

On Reptilian Remains found in the Old Red Sandstone of Morayshire.

1. *Notice of the Discovery of Reptilian Foot-tracks and Remains in the Old Red Sandstone of Morayshire.* By Captain LAMBERT BRICKENDEN, F.G.S.

On the coast of Morayshire, between the villages of Covesea and Burghead, strata of crystalline sandstone occur in great thickness, and are regarded as belonging to the upper division of the Old Red or Devonian formation of Scotland. The only fossil discovered in this rock was the imprint of a mass of scales or scutes of a remarkable ganoid fish, named *Stagonolepis*, by M. Agassiz, until 1850, when the author observed on a block of sandstone, in a quarry at Cummingstone, a distinct series of quadrupedal footprints, traced in an uninterrupted succession across the slab. The imprints are thirty-four in number, and the track of the right feet alternates with that of the left. These impressions have a rounded form, and are identical with those which are generally regarded as chelonian footprints by palæontologists. In October 1851, from a quarry of sandstone at Spynie Hill, Mr Patrick Duff, of Elgin, obtained a beautiful imprint of the skeleton of a four-footed reptile, about five or six inches in length, and which that gentleman allowed the author to transmit to Dr Mantell to describe, as an appendix to the present communication. The author states that, on finding the chelonian foot-tracks in rocks of an age in which no traces of the class *Reptilia* had previously been discovered, a strict investigation took place as to whether the sandstone strata, from which the slab was taken, are unquestionably referable to the Devonian formation, to which they had always been supposed, by Mr Hugh Miller and other competent observers, to belong. The discovery of the reptile at Spynie dispelled all doubt on this point; for the beds of Cummingstone and Spynie are identical, and, at the latter place, are capped by the cherty limestone peculiar to the upper division of the old red of the district. The *Stagonolepis*, found in the same rocks, is emphatically an old red sandstone family of fishes, and confirms the above inferences. The author concludes with the remark that, by the discovery of the chelonian footsteps and the reptile of Spynie, we have thus for the first time obtained unquestionable evidence that two orders of the class *Reptilia* existed during the Devonian epoch.

2. *On the Telerpeton Elginense, a Fossil Reptile discovered in the Old Red Sandstone of Moray.* By Mr PATRICK DUFF; *and on supposed Fossil Ova of Batrachians in the lower Devonian Shales of Forfarshire.* By Dr MANTELL, LL.D., F.R.S., &c.

The reptile from Spynie, referred to by Captain Brickenden in the foregoing paper, consists of the impression of the skeleton in a block of sandstone, which is broken into three pieces. The cranium is but obscurely seen. Of the rest of the skeleton scarcely an atom of the osseous substance remains. The impression of the spinal column from the occiput to the pelvis, consisting of twenty-four vertebræ, each supporting a pair of slender ribs, of the left humerus, radius, and ulna, of the femoral and leg bones, of the pelvis, and of a considerable portion of the caudal series of vertebræ, serve to convey a general idea of the form and structure of the original. The author gave a description of its anatomical characters, so far as they can be ascertained from the imperfect state of the specimen, and the result of a comparison with recent forms. He specifies certain osteological characters which are *Lacertian*, and others that are *Batrachian;* and he concludes that the original was a peculiar type, which, in the present state of our knowledge, it would be rash to pronounce to belong to either order; and he distinguishes it by a name simply expressive of its high antiquity—*Telerpeton* (τηλε ἑρπετον), with the specific term *Elginense*, to denote the locality in which it was discovered. The original was an air-breathing, oviparous quadruped, probably resembling in appearance an aquatic salamander, but with longer limbs and a wider dorsal region than our Tritons, and capable of rapid progression on land and in the water. In connection with the above discoveries, the author states that the Devonian shales of Forfarshire abound with clusters of small, round, carbonaceous bodies, which are commonly associated with aquatic plants. These fossils have been figured and described as being probably ova of gasteropodous molluscs, although neither shells nor casts of shells of any kind have been found in the strata. The discovery of reptiles in the upper member of the Old Red of Scotland led Dr Mantell to recur to an idea he formerly entertained, that the Forfarshire fossils were the spawn of Batrachians of the family Ranidæ; and upon comparing them with a mass of carbonized recent frogs' eggs, the resemblance was found to be so complete as to induce him to conclude that the fossil eggs are referable to reptiles and not to molluscs. In conclusion, the author dwells on the importance of the researches of Captain Brickenden and Mr Duff in a palæontological point of view; for they establish the existence during the Devonian or Old Red epoch of several orders of a higher class of vertebrate animals than had previously been discovered; while the occurrence of Batrachian ova with aquatic plants, associated with remains of ganoid fishes, which, for aught that is known to the contrary, may have been inhabitants of fresh water, like the existing *Lepidostei*, together with the entire absence of marine organisms, suggests the probability that the Devonian strata thus characterised, may be of fluviatile origin.

The Silurian System.

As we have inserted in this number of the Edinburgh New Philosophical Journal a short account of Professor Sedgwick's view of the Older Palæozoic Rocks of Great Britain, but chiefly those of the Cambrian System, we think it proper to give a place to the following letter, addressed by Sir R. Murchison to the Literary Gazette of the present date, on the Silurian System:—

As the abstract of a memoir by Professor Sedgwick on the Palæozoic rocks, which appeared in your journal of the 6th, might lead some of your readers to suppose that the Silurian system is a baseless fabric which requires reconstruction, I beg permission to state the substance of the reply which I made *vivâ voce* at the rooms of the Geological Society, to the points advanced by my old friend, who has become an antagonist—the only one, however, I am acquainted with—to views which are, I trust, firmly established.

Divested of numerous local names, the proposition now brought forward (seventeen years after the promulgation of the Silurian nomenclature)* is, that a very large portion of the lower Silurian rocks described by me as the 'Llandeilo' formation, be transferred to the so-called 'Cambrian rocks.' On my part, I contend that geologists must adhere to my nomenclature, founded on data which have proved to be true—a nomenclature that has been generally adopted at home and abroad.

The few arguments required to sustain this position will be intelligible to every one. Let those who wish to comprehend what the Silurian system is considered to be by leading geologists, repair to the great and instructive geological museum in Jermyn Street. There they will see that all the inferior slates and limestones of North Wales which contain fossils are named Lower Silurian. They will also see that in the coloured maps and sections illustrative of North Wales, Lower Silurian rocks are represented to extend nearly all over that region; the only strata to which the term Cambrian is applied, being certain masses of *un*fossiliferous greywacke, which, like my Longmynd in Shropshire, rise from *beneath* the lowest fossil-bearing rocks. Why, then, did Sir Henry De la Beche, and his followers in the field, Ramsay, Aveline, Selwyn, and others, adopt this classification? and why has it been confirmed by Edward Forbes, Phillips, Salter, and the palæontologists of the Survey? Simply, that after a long and careful scrutiny these observers have satisfied themselves that the region called Cambria, at a time, it will be recollected, when none of its fossils were described, is made up of the same strata, and contains the same organic remains, as the lower Silurian rocks, whose contents were so long ago described by myself. Inquiries and researches in various parts of Europe, in which I have taken part, and in America and other countries, have been followed by similar results; and as the lower Silurian types of life have everywhere proved to be the oldest, the term Cambrian has never yet been applied to strata characterised by any group of animals peculiar to them.

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* See Philosophical Magazine, 1835, with table, &c. The large work really followed in 1838 (date of Preface), though 1839 is on the title page.

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The adoption of the proposal of Professor Sedgwick would, in truth, destroy the Silurian system of rocks. For whilst he leaves me the Caradoc sandstone, he would cut away from it the next underlying formation, or my own Llandeilo flags; though it is known to every one who has worked in these primeval rocks, that *many of the same species of shells and trilobites characterise both the Caradoc and Llandeilo formations.* How, then, is the geologist to draw any line of separation through the middle of a group, the members of which are thus naturally united? How call one part of it Silurian, and another Cambrian? How, indeed, break up a natural system of life in which a great number of fossils are found to be common to its upper and lower divisions?

That the Silurian base-line, on which Professor Sedgwick lays so much stress, was inaccurately defined in many parts when my labours in Siluria terminated, is very true; but it was essentially correct in Shropshire, and all that might lie beneath it was left to himself to determine. The chief phenomena I described in Siluria, after seven years of labour, have stood the test of time; and a companion whose friendship I shall never cease to value, must not lay to my door the loss of a Cambrian kingdom, in the occupation of which I had no share. Its invaders have been the geological surveyors, who literally could not do otherwise than interpret a region (the fossil contents of which had never been delineated) except by comparing it with tracts long well known, through my detailed descriptions of their rocks and fossils. These surveyors have shewn, that the very strata which in Shropshire and Montgomeryshire I described as lower Silurian, to the west of my "Cambrian" Longmynd, roll over in great undulations to Snowdon itself. Hence it is now useless to refer back to the inaccurate portion of a line of boundary on my old map, which is little more than a demarcation between my own hunting-grounds and those of my friend. Cambria was, indeed, his own country, in which, amid grand contortions of the rocks, he had ably mastered many physical difficulties besides those of slaty cleavage: and I respected this territory, in the full persuasion that its strata would prove to be of higher antiquity than my own, and, if so, that their *contents would be distinct.* The appeal to nature by our associates has decided otherwise.

When we take leave of Wales, where the tombs of primeval life are obscured by numerous sheets of porphyry and other igneous rocks, how clearly do we read in the book of nature, opened out in the north of continental Europe, that Silurian fossils constitute the earliest recognisable creation. This fact I have explained in the first chapters of " Russia and the Ural Mountains." It is also proved in the works of Barrande on Bohemia, Hall and other geologists in the United States, and in Canada by Logan. In all these countries, as well as in France and Spain, where they have been analysed by De Verneuil and his countrymen, or in Portugal, where they have been recognised by Daniel Sharpe, the lowest discoverable fossils have been invariably identified as Silurian; whilst Bronn, in Germany, and D'Orbigny, in France, have so tabulated them.

In conclusion, I may remark, that if my friend's suggestion were capable of adoption, a result must follow, which even in his zeal to *animate* his Cambrian rocks, he could not wish to carry out—viz., the erasure of the word Silurian from the geological maps of the continent of Europe, and even from those of Scotland and Ireland! In most of these regions, wherever Silurian rocks exist, it is their lower part only which prevails; and hence all such strata may be claimed as Cambrian, on the very same grounds as those which recently induced Professor Sedgwick to term " Cambrian" a ridge of rocks in South Cornwall, which, from its well-known imbedded fossils, was pronounced by me to be Silurian, in 1846. On the same principle, the tracts of the north of Ireland, described as Silurian by Portlock, must now change to " Cambrian;" and even the very Irish fossils collected by Griffith,* and named Silurian by that author and M'Coy, must be rebaptized. These, and the great mass of the Scottish and continental rocks of this age, offer scarcely any representatives of the upper Silurian group; and hence, if deprived of all lower Silurian strata, the now wide-spread Silurian system would be almost restricted to the borders of England and Wales, a part of Cumberland, and the island of Gothland.

As this must inevitably be the issue, if the proposed division of the older British rocks were generally applied, I have been compelled to state my objections plainly, and to point out the confusion and vast changes which must ensue, if a nomenclature be disturbed, which, founded on a natural arrangement, has been extended by my contemporaries to all quarters of the globe.

RODERICK IMPEY MURCHISON.

P.S.—The following poetical squib from the pen of a mutual friend and a profound naturalist, who listened to the recent discussion on this subject, at the Geological Society, may prove more effective than my prose, in sustaining the rights of Siluria and Caractacus:—

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* Author of the Geological Map of Ireland.

> "Silurian beds we in myriads number,
> Cambrian strata 'stat nominis umbra,'
> S. says M. knows not his beds when he's got 'em,
> That his system is base, and his base has no bottom;
> Whilst M. makes appeal to the sense of mankind,
> Whether he should be stifled, 'cause S. lagg'd behind."

SCIENTIFIC INTELLIGENCE.

METEOROLOGY.

1. *Five Hundred Persons destroyed by a Water-Spout.*—On Saturday intelligence was received at Lloyd's, under date Malta, Monday, the 8th instant, of a most awful occurrence at the island of Sicily, which had been swept by two enormous water-spouts, accompanied by a terrific hurricane. Those who witnessed the phenomena describe the water-spouts as two immense bodies of water reaching from the clouds, their cones nearly touching the earth, and, as far as could be judged, at a quarter-of-a-mile apart, travelling with immense velocity. They passed over the island near Marsala. In their progress houses were unroofed, trees uprooted, men and women, horses, cattle, and sheep were raised up, drawn into their vortex, and borne on to destruction: during their passage rain descended in cataracts, accompanied with hailstones of enormous size, and masses of ice. Going over Castelamare, near Stabia, it destroyed half of the town, and washed 200 of the inhabitants into the sea, who all perished. Upwards of 500 persons have been destroyed by this terrible visitation, and an immense amount of property, the country being laid waste for miles. The shipping in the harbour suffered severely, many vessels being destroyed, and their crews drowned. After the occurrence, numbers of dead human bodies were picked up, all frightfully mutilated and swollen.

GEOLOGY.

2. *Sir Charles Lyell on Progressive Geological Development.*—Sir Charles Lyell in a lecture read at Ipswich a short time ago, on Progressive Development, concluded by explaining the theory which he had advocated in his works, in opposition to that of progressive development. He believed that there had been a constant going out and coming in of species, and a continual change going on in the position of land and sea, accompanied by great fluctuation in climate; that there had been a constant adaptation of the vegetable and animal creations to those new geographical and climatal conditions. At the present moment we found contemporaneously a marsupial fauna in Australia, and mammalia of a different and higher grade in Asia and Europe; we also found birds without mammalia in New Zealand, reptiles without land quadrupeds in the Galapagos Archipelago, and land quadrupeds without reptiles in Greenland. In like manner, in successive geological eras, certain classes, such as the rept

may have predominated over other vertebrata throughout wide areas; but there is no evidence that the adaptation of the fauna, as above explained, had been governed by any law of progressive development. In those classes of the invertebrata which were best known, and fully represented in a fossil state at all geological periods, the oldest or Silurian fauna was as highly developed as the corresponding fauna in the recent seas. Our ignorance of the inhabitants of the ancient lands was the chief cause of our scanty acquaintance with the highly-organised beings of remote epochs.—(*Literary Gazette*, No. 1824, p. 17.)

3. *Desor on the Drift of North America.*—The drift is the last phase of any importance through which the earth passed before it became fitted for the habitation of man. Were it not for these deposits, a great portion of this continent, including the district embraced in this report, would have been a waste of naked and barren rocks, covered partially with heaps of dry sand, or rough detrital materials. Through the long-continued agency of water, these materials have not only been reduced and dispersed, but also mingled in such proportions as to afford a most appropriate soil for vegetable and animal life. When afterwards the rise of the continent caused the waters to recede within their present limits, they left behind them those wide drift-covered plains, destined to become, in the lapse of time, the seat of an industrious, intelligent, and prosperous nation. We think ourselves justified in considering the period when the waters, after having done their work, began to recede, as the beginning of that new and grand era which has been properly called the *Era* of Man, and of which the alluvial period is the introduction.—(*American Journal of Science and Arts*, vol. xiii., No. 37, 2d Series, p. 109.)

4. *Lieut. Charles Henry Davis on the Connection between Tides and Alluvial Deposits.*—So long ago as September 1848, he wrote, "I have recently arrived at some interesting conclusions concerning the connection between the tides and other currents, and the alluvial deposits in the depths and on the borders of the ocean; and my views bear out the theory that attributes the principal changes in the conditions of the earth's surface to causes now in operation. I am able, I believe, to shew a permanent and mutual relation between the local and general tides on the one hand, and the eastern border of the United States on the other; between the shores of the Gulf of Mexico, and the currents by which they are washed. The sandy deposits on the Atlantic border are remarkable in outline as well as in quantity. A narrow strip on the coasts of Florida and Georgia spreads out into those prominent capes and enormous banks and shoals which give such a peculiar character to our navigation. On the shores of Europe the vast deposits of similar material at the bottom of the Bay of Biscay, and in the North Sea, are to be traced to the same laws of tidal action. The theory will also account for simi-

lar deposits elsewhere, and for banks and shoals composed of the coralline detritus in the Indian Seas." Since this was written, Lieut. Davis has given the American Academy his views on what may be termed Tidal Geology, and the consequent formation of shoals, banks, bars, beaches, nooks, and sea-walls; and he has succeeded in tracing the effects of great causes through all their mysterious phases, with the cautious observation and inductive experiment which science demands.—(*Journal of the Royal Geographical Society of London*, vol. xxi., p. xcii.)

5. *Different Gneiss Formations.*—Many years ago we observed in our Highlands, gneiss associated with conglomerate, and great veins of gneiss traversing gneiss. These facts have been verefied by the discovery of similar phenomena in other countries. In this note we have only space for the following. Gneiss is now divided into the following formations: 1. *Primary gneiss*, that associated with certain granites, and forming the fundamental or oldest formation of the crust of the earth; 2. *Transition gneiss*, that which rests upon transition rocks, as greywacke, clay-slate, and old red sandstone, and even alternates with them; 3. *Secondary gneiss*. This formation rests upon lias, and is well seen in Switzerland. We have no intimation that gneiss has been met in the tertiary class.

6. *Pseudomorphic Nature of Serpentine.*—Many years ago Steffens and Jameson noticed the gradual transitions from trap to serpentine, as observed in Germany and Scotland. Very lately the celebrated George Rose of Berlin has illustrated this important view in a very interesting manner.—(*Leonhard and Bronn's Jahrbuch*, 5 *Heft*, 1851.)

7. *Cause of the Thermal Waters in Western Asia-Minor.*—The cause of the abundance of warm springs in this quarter of the globe, in all formations from the alluvial to the oldest rocks, is doubtless owing to the extensive igneous action within no great depth beneath the surface of the country; a fact evinced by the frequency of earthquakes, but more especially by their extent; for they almost invariably extend from one end of it to the other, as well as to the neighbouring islands.

Neither time nor change of government has contributed so much to the destruction of the hundreds of magnificent cities which once covered this country, as the desolating influence of the earthquake; and many are the cities that now exist, which have been prostrated over and over again, and rebuilt, each time in diminished splendour, until at last they are little better than collections of huts, when contrasted with their original condition. All the country at the present day seems to be as much subject to them as formerly.

The only part of Western Asia-Minor where phenomena are seen strictly analogous to those of active volcanoes, is in the *Catacecaumene* or Burnt district, situated in Lydia, about one hundred miles *east* of Smyrna. Numbers of volcanic cones exist in the neighbourhood of *Koola*, of many of which the craters are quite distinct, especially the one called *Kalar Alan*, which has a perfect crater about half a mile in circumference, and two or three hundred feet deep. The extent of this region is some twenty miles long by eight broad. We have no record of any activity in these volcanoes, and Strabo described them in his day quite as they are now, and the Turks give to Satan the full credit of having created such a bleak parched-up district. My object at the present time is merely to mention this district, as a full description of it enters into a paper on the Earthquakes and Volcanoes of Asia-Minor, that I propose publishing at some future time; it is brought forward now merely to shew what this volcanic centre has to do with the thermal springs just described.—(*The American Journal of Science and Arts*, vol. xii., No. 36, 2d Series, p. 375.)

MINERALOGY.

8. *Tourmaline, its different kinds.*—Rammelsberg divides the mineral named Tourmaline into two groups. 1*st*, The so-called dark or black tourmalines, characterised by the absence of lithion, and the greater and lesser quantity of iron. 2*d*, The transparent variously-coloured tourmalines, which always contain lithion, and are sometimes free of iron.

These groups fall into the following sub-groups.

1. *Magnesia—Tourmaline*—brown, yellow; contain much magnesia and little iron.

2. *Magnesia—Iron—Tourmaline*; the most frequent, the black; less magnesia and more iron.

3. *Iron—Tourmaline*—maximum of iron; under the sub-group we include the Tourmaline of Sonnenberg near Andreasberg, and that of Langenbielau.

4. *Magnesia—Iron—Tourmaline*—colours violet blue, green, and blue; contains lithion, manganese, and little iron.

5. *Manganese—Tourmaline*—colour red; contains no iron.

9. *R. Hermann's Arrangement of Minerals of the Felspar kinds.*

Family of Felspars.

I. *Orthoklase Group.*

1. Orthoklase, *a.* Feldstein; *b.* Common Felspar; *c.* Adularia; *d.* Glassy Felspar.

2. Loxoklas. 3. Ryakolite.

II. *Albite Group.*

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4. Albite. 5. Oligoklas. 6. Andesine. 7. Lepolite.

* *

8. Hyposklerite. 9. Labrador. 10. Anorthite.

* * *

Amphodelite—Bytownite—Latrobite—Indianite—Linseite.

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The following minerals probably belong to the Felspar Family, viz., Saccharite—Barsowite—Couzeranite—Saussurite.—(*Bronn, Jahrbuch*, 4 *Heft*, 1851.

ZOOLOGY.

10. *The Animals of a Coral Reef, by John Magillivray, Esq.*—During our stay we were fortunate in having fine weather, light winds, and low tides, which enabled such as were inclined to look for shells upon the reef, to do so under the most favourable circumstances. This reef is of a great extent, with all the varieties of coral, mud, and sand, and proved a most productive one. A sketch of the distribution of the principal of its productions may be of interest to some. Many kinds of fishes, Murena, Diodon, Balistes, Serranus, &c., are found in the pools among the coral blocks; the first of these, of bright colours, variously striped and spotted, resemble water snakes, and are exceedingly active, gliding through the interstices in the coral, and hiding in its hollows,—they bite savagely at a stick presented to them, and are by no means pleasant neighbours while wading about knee deep, and with bare arms turning over the coral which they frequent. On a former occasion I had been laid hold of by the thumb, and the wound was a long time in healing. Crustacea are also numerous; blue and green *Gonoductyli* leap about with a sharp clicking noise—legions of *Mycteris subverrucata* traverse the dry sands at low water—and in the shallow muddy pools, dull green Thalamitæ and Lupeæ swim off rapidly, and smooth Calappæ seek refuge by burrowing under the surface.

Of mollusca, two species of olive (*O. erythrostoma* and *O. leucophæa*) were found on the sandy margin of the islet—several *Cerithia* and *Subulæ* (*S. maculata* and *S. occulata*) creep along the sand flats, and, with some fine *Naticæ*, and a *Pyramidella*, may be found by tracing the marks of their long burrows. Several *Strombi* and *Nassa coronata* inhabit the shallow sandy pools; the egg-shell and many *Cypræidæ* occur under coral blocks, which when over sand, often harbour different kinds of cones—of which the handsome *C. textile* is the commonest. A delicate white lima (*L. fragilis*) is abundant here, merrily swimming away in the pool under an upturned stone, and leaving its fringe-like tentacles adhering to the hand when seized. Lastly, it would be improper to omit mentioning the very fine oysters adhering to the roots of the mangroves. But these are only a small portion of the shell-fish collected here. Among radiate animals, several *Ophiuræ* and *Ophiocomæ* and other *Asteriadæ*, with two kinds of *Echinus*, are also plentiful under blocks of coral (*Astræa* and

Meandrina) in the pools; one of the last, remarkable for its very long, slender, black spines, has the power of giving an exceedingly painful puncture, if carelessly handled—for a few minutes the sensation is similar to that caused by the sting of a wasp; of the others, a fine *Ophiura* is remarkable for its great size and grass-green colour, and an *Ophiocoma* for the prodigious length of its arms.—(*Voyage of H. M. S. Rattlesnake*, vol. i., p. 102. *Commanded by the late Capt. Owen Stanley. By J. Macgillivray.*)

11. *Cause of the Jet from the Blow-Holes of Whales.*—At a meeting of the Boston Society of Natural History, for February, Dr Wyman made some remarks on the probable cause of the jet from the blow-holes of whales. While on a recent visit to Labrador, he had an opportunity of observing this phenomenon. Three causes for this jet had been assigned, namely, the water taken into the mouth with the food of the animal, the water in the nasal cavities, and the secretions of the bronchial tubes. As it appears in the form of a sudden discharge of vapour, he thought a fourth explanation might be added,—the sudden rarefaction of the air when inhaled, followed by a sudden condensation when emitted. He thought it was partly due also to the small quantity of water which entered the outer extremity of the nasal passages. He had succeeded in imitating the appearance in question, by introducing a small quantity of water into the end of a syringe and suddenly expelling it, with the body of air behind it, with considerable force.

Dr Pickering said he could not think the condensation of the air when expelled from the lungs of a whale was a circumstance of much importance in forming the jet, as in tropical climates, where this could hardly occur, the jet was as complete as in colder latitudes.

Dr Wyman said, that in some instances he heard the inspiration as well as the expiration of Cetacea. It follows the expiration instantaneously, but it is much shorter and less audible.

Mr Ayres, from his own observations, confirmed Dr Wyman's views. He had noticed in a young porpoise that the act of breathing is much more slowly performed than in the adult.—(*American Journal of Scientific Discovery for* 1851, p. 337.)

BOTANY.

12. *On the Palo de Velus or Candle-Tree* (*Parmentiera cereifera*, Seem.) *By M. Berthold Seemann.*—This tree is confined to the valley of the Chagres, where it forms entire forests. In entering them, a person might almost fancy himself transported into a chandler's shop. From all the stems and lower branches hang long cylindrical fruits, of a yellow wax colour, so much resembling a candle, as to have given rise to the popular appellation. The fruit is generally from two to three, but not unfrequently four, feet long, and an inch in diameter. The tree itself is about twenty-four feet high, with opposite trifoliated leaves and large white blossoms, which appear

throughout the year, but are in greatest abundance during the rainy season. The *Palo de Velas* belongs to the natural order *Crescentraceæ*, and is a *Parmentiera*, of which genus, hitherto, only one species, the *P. edulis*, De Cand., was known to exist. The fruit of the latter, called *Quanhscilote*, is eaten by the Mexicans; while that of the former serves for food to numerous herds of cattle. Bullocks, especially if fed with the fruit of this tree, Guinea-grass, and *Batatilla* (*Ipomæa brachypoda*, Benth.), soon get fat. It is generally admitted, however, that the meat partakes in some degree of the peculiar apple-like smell of the fruit; but this is by no means disagreeable, and easily prevented, if, for a few days previous to the killing of the animal, the food is changed. The tree produces its principal harvest during the dry season, when all the herbaceous vegetation is burned up; and on that account its cultivation in tropical countries is especially to be recommended; a few acres of it would effectually prevent that want of fodder, which is always most severely felt after the periodical rains have ceased.—(*Hooker's Journal of Botany.*)

MISCELLANEOUS.

13. *The Sources of the Nile.*—At the last meeting of the Bombay Geographical Society, a paper was read by Mr John Smith on the discoveries made by the East African Missionaries on what appear to be the Sources of the Nile. This mysterious river is said to arise from two lakes, one of which is of great dimensions nearly under the line, and they seem fed by the melting snows of the gigantic range, which rises to the altitude of 22,000 feet at least, close by. The description of this long looked for locality coincides exactly with that given of it by Ptolemy, two thousand years ago.—(*The Bombay Times, February 18th* 1852.)

14. *Bonpland the Botanist.*—An American traveller has sent an account to the Geographical Society at Paris, of his meeting with M. Bonpland, Humboldt's celebrated companion, near San Borga, where he lives happily with his family, constantly making additions to his Herbarium, which he considers as belonging to France, and which contains at least 3000 plants; the collecting of it seems to have obliterated the bitterness of his forced detention by Dr Francia. —(*Journal of the Royal Geographical Society*, vol. xxi., p. 93.)

15. *The Shortening of Voyages between the Old and New Worlds.*—Much attention has been paid in America towards impinging upon time and space, as respects the communication between the Old and the New Worlds; and especially as to shortening the time of passage between New York and London. The most received project is founded on the fact, that railroads are three times as expeditious as steamers; consequently, instead of embarking at New York, it is proposed that passengers should proceed by land as far eastward as a railroad can be carried—that is, to the utmost verge of Nova

Scotia—and there embark. They then should make the best of their way to Galway Bay, and take the railway for Dublin. Now, after what has been achieved in international communication of late, we may reasonably hope for farther improvements. A voyage to the East Indies and back in former times occupied a couple of years or more ; ordinary merchantmen can now manage the same in nine months. In 1750, a time when the trade-winds where pretty well understood, three fine Indiamen—the "Ilchester," "Anson," and "Shaftesbury," sailed from the Downs on the 5th of April, and arrived at Bombay in September : in 1850 the same voyage is averaged to occupy 75 days, and news is carried by the overland mail in less than a month. This is owing to a proper application of science and experience; and I cannot but augur that Lieut. Maury's inquiries, as shewn in the charts I mentioned, will still further abridge our longest oceanic voyages.—(*Journal of the Royal Geographical Society*, vol. xxi. p. 90.)

16. *On the mode of manufacturing Pemmican.*—In April 1847, I had the advantage of an interview with Sir George Simpson, Governor-in-chief of Rupert's Land, who was then on a visit to England, and of concerting with him the measures necessary for the future progress of the expedition ; and I may state here that he entered warmly into the projects for the relief of his old acquaintance Sir John Franklin ; and from him I received the kindest personal attention, and that support which his thorough knowledge of the resources of the country and his position as Governor enabled him so effectively to bestow. He informed me that the stock of provisions at the various posts in the Hudson's Bay territories was unusually low, through the failure of the bison hunts on the Saskatchewan, and that it would be necessary to carry out pemmican from this country, adequate not only to the ulterior purpose of the voyage to the Arctic Sea, but also to the support of the party during the interior navigation in 1847 and 1848. I therefore obtained authority from the Admiralty to manufacture, forthwith, the requisite quantity of that kind of food in Clarence Yard ; and as I shall have frequent occasion to allude to it in the subsequent narrative, it may be well to describe in this place the mode of its preparation. The round or buttock of beef of the best quality, having been cut into thin steaks, from which the fat and membranous parts were pared away, was dried in a malt-kiln over an oak fire, until its moisture was entirely dissipated, and the fibre of the meat became friable. It was then ground in a malt-mill, when it resembled finely grated meat. Being next mixed with nearly an equal weight of melted beef suet or lard, the preparation of plain pemmican was complete ; but to render it more agreeable to the unaccustomed palate, a proportion of the best Zante currants was added to part of it, and part was sweetened with sugar. Both these kinds were much approved of in the sequel by the consumers, but more especially that to which

the sugar had been added. After the ingredients were well incorporated by stirring, they were transferred to tin canisters, capable of containing 85 lb. each; and having been firmly rammed down, and allowed to contract further by cooling, the air was completely expelled and excluded by filling the canister to the brim with melted lard, through a small hole left in the end, which was then covered with a piece of tin, and soldered up. Finally, the canister was painted and lettered according to its contents. The total quantity of pemmican thus made was 17,424 lb., at a cost of 1s. 7¼d. a pound. But the expense was somewhat greater than it would otherwise have been, from the inexperience of the labourers, who required to be trained, and from the necessity of buying meat in the London market at a rate above the contract price, occasioned by the bullocks slaughtered by the contractor for the naval force at Portsmouth being inadequate to the supply of the required number of rounds. Various temporary expedients were also resorted to in drying part of the meat, the malt-kiln and the whole Clarence Yard being at that time fully occupied night and day in preparing flour and biscuit for the relief of the famishing population of Ireland. By the suggestions of Messrs Davis and Grant, the intelligent chief officers of the victualling yard, and their constant personal superintendence, every difficulty was obviated.

As the meat in drying loses more than three-fourths of its original weight, the quantity required was considerable, being 35,651 lb.;* and the sudden abstraction of more than one thousand rounds of beef from Leadenhall market occasioned speculation among the dealers, and a rise in the price of a penny per pound, with an equally sudden fall when the extra demand was found to be very temporary.†

The natives dry their venison by exposing the thin slices to the heat of the sun, on a stage, under which a small fire is kept, more

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* By drying, this was reduced to about 8000 lb.

† Particulars of the estimated expense of pemmican manufactured in the Royal Clarence Victualling Yard in midsummer quarter 1847:—

Fresh beef,	35,651 lb.	at 6¾d. per lb.	£979	10	1			
Lard,	7,549 ...	at 88s. per cwt.	296	11	4			
Currants,	1,008 ...	at 84s. per cwt.	37	16	0			
Sugar,	280 ...	at 31s. 2d.	3	17	11			
						£1317	15	4
Oak slab, 46 fms. at 22s. 6d. per load,			£47	5	0			
Hire for labourers,			59	8	8			
Hire of kiln and cartage,			8	1	0			
						114	14	8
						£1432	10	0
Deduct for scraps of fat sold,						35	18	1
						£1396	11	11

Quantity of pemmican manufactured, 17,424 lb.; average cost per lb., 1s. 7¼d.

for the purpose of driving away the flies by the smoke than for promoting exsiccation; and then they pound it between two stones on a bison hide. In this process the pounded meat is contaminated by a greater or smaller admixture of hair and other impurities. The fat, which is generally the suet of the bison, is added by the traders, and they complete the process by sewing up the pemmican in a bag of undressed hide with the hairy side outwards. Each of these bags weighs 90 lb., and obtains from the Canadian voyagers the designation of "an taureau." A superior pemmican is produced by mixing finely powdered meat, sifted from impurities, with marrow fat, and the dried fruit of the Amelanchier.—(*Sir J. Richardson.*)

17. *Important Uses of Iodiferous Compounds.*—From the important researches of M. Bousingault, it appears that the inhabitants of the Cordilleras of New Granada, where cretinism and goitre are endemic, now avert these evils by the use of an iodiferous salt extracted from the numerous saline springs of that country; and M. A. Fourcault recommends to the inhabitants of mountain districts, where goitre and cretinism are endemic, the use of iodurite of potassa along with common salt: he is also of opinion, that iodurets will prove very useful in districts where scrofula and pulmonary consumption prevail.

18. *On the Application of Rectified Oil of Coal-Tar to the Preservation of Meat and Vegetables. By M. Robin.*—When the flesh of animals, entire birds with the feathers, vegetables, fruits, &c., are placed in air-tight vessels filled with water, at the bottom of which there is a little oil of coal-tar, so that the substances to be preserved are covered by the water, which becomes charged with the vapour of the oil evaporating at the ordinary temperature, they are perfectly preserved from decomposition.—(*Comptes Rendus*, vol. xxxii., p. 650.)

19. *Lapland.*—"At the beginning of June, I left Helsingfors for Uleaborg, about eighty Swedish miles, or six hundred and forty English. In the latter town, I had to provide myself with a suitable outfit for Lapland—tents, provisions to cook, &c. There remained yet two hundred English miles to Kunsama Kimbe. The distance took us six or seven days, though hitherto we had travelled at the rate of eight miles an hour. The stations where we could procure horses became fewer and fewer, and frequently I was obliged to wait one or two days for horses. At Kunsama Church, all roads were at an end, and thence I was obliged to travel either on the lakes and rivers, or on foot. When I say I am now in Lapland, I am wrong; for in this parish no Laplanders have lived within the last hundred years. Finnish colonists have pressed them on farther north, somewhat as has been done with some Indians. They have here some little agriculture (rye), and a few settlements. From ten to twenty miles farther north, we have the true Laplanders, who roam about with their rein-deer. The scenery here partakes, how-

ever, entirely of the Lapland features. Summer lasts only from ten to twelve weeks; and in December the day lasts from eleven till two o'clock, and even these three hours are not what we would call daylight, but rather a kind of twilight. A few miles further on, they do not see the sun at all for a whole month. The population here is very sparse; fishing and breeding of cattle furnish the only means of subsistence. Rein-deers are much used: a rich peasant has from three to four hundred; the Laplanders several thousand. Very few are seen here in summer, for as soon as the snow thaws in spring, they are driven into the forests. In autumn, almost the whole population go out; a large space is fenced in, and after tedious driving, they collect the half-wild rein-deer, and each individual selects his own—they are all marked—and takes them home. The whole winter the rein-deer keep round the bays and inlets, and feed themselves by scraping out the moss from under the snow, and the peasants, consequently, do not have to look out for their feeding. For the winter, some dozen or two are broken in for the harness, for there are few horses here, and higher up none. A rein-deer sledge (in Laplandish *pulka*) is shaped like a boat (conat). Reins are not used as with horses, only a strap round the neck. The animal may be in quickest motion, but so soon as I pull the strap to the side, it stands still. In driving in the *pulka*, we make use of cloaks of rein-deer hide, through a hole in which the head is thrust. * * * Almost the whole of June, I could see the sun all night from the hill-tops, considerably above the horizon. Night was as light as day, and I could make the most careful drawings and minute examinations of minerals. In June and July we had intense heat, accompanied by innumerable gnats and flies. The peasants guard themselves against these tormentors by covering their face and hands with tar. I had a mask of gauze."—(*Silliman's Journal*, vol. xi., 2d Series, p. 136.)

List of Patents granted for Scotland from 22*d December* 1851 *to* 24*th March* 1852.

1. To James Macnee, of Glasgow, in the county of Lanark, North Britain, merchant, "improvements in the manufacture or production of ornamental fabrics."—26th December 1851.

2. To Jean Antoine Farina, of Paris, in the state of France, proprietor, "a process for manufacturing paper from a certain material."—26th December 1851.

3. To Francis Hastings Greenstreet, of Albany Street, Mornington Crescent, in the county of Middlesex, "improvements in coating and ornamenting zinc."—29th December 1851.

4. To Frederick Rosenborg, of the Albany, in the county of Middlesex, Esq., "improvements in the manufacture of casks, barrels, and other like articles, and the machinery employed therein."—2d January 1852.

5. To James Aikman, of Paisley, in the county of Renfrew, North Britain, calenderer, "improvements in the treatment or finishing of textile fabrics and materials."—6th January 1852.

6. To James Gathercole, of Eltham, in the county of Kent, envelope manufacturer, "improvements in the manufacture and ornamenting of envelopes, parts of which improvements are applicable to other descriptions of stationery, and in the machinery, apparatus, or means to be used therein."—8th January 1852.

7. To Edwin Rose, of Manchester, in the county of Lancaster, engineer, "certain improvements in boilers for generating steam."—9th January 1852.

8. To Thomas Richardson, of Newcastle-upon-Tyne, "improvements in the manufacture or preparation of magnesia and some of its salts."—24th January 1852.

9. To James Warren, of Montague Terrace, Mile-end Road, gentleman, "improvements applicable to railways and railway carriages, and improvements in paving."—13th January 1852.

10. To Alexander Parkes, of Birmingham, "improvements in separating silver from other metals."—13th January 1852.

11. To Alexander Hediard, of 25 Rue Taitbont, Paris, France, improvements in propelling and navigating ships, boats, and vessels, by steam and other motive power."—16th January 1852.

12. To Aimé Nicholas Derode, of No. 37 Rue St Roche, Paris, France, gentleman, "a certain process for uniting cast-iron to cast-iron and to other metals, and for uniting other metals together."—26th January 1852.

13. To George Torr, of the Chemical Works, Trunley's Lane, Rotherhithe, animal charcoal burner, "improvements in reburning animal charcoal."—26th January 1852.

14. To James Pillans Wilson and George Ferguson Wilson, both of Wandsworth, in the county of Surrey, gentlemen, "improvements in the preparation of wool for the manufacture of woollen and other fabrics, and in the process of obtaining materials to be used for that purpose."—26th January 1852.

15. To Victor Lemoign, of Cette, department of l'Herault, in the republic of France, "certain improvements in rotary engines."—26th January 1852.

16. To John Stopporton, of Douglas, in the Isle of Man, engineer, "certain improvements in propelling vessels, parts of which improvements are applicable to steam-engines and pumps."—28th January 1852.

17. To Joseph Stenson, of Northampton, in the county of Northampton, engineer and iron-manufacturer, "improvements in the manufacture of iron, and in the steam-apparatus used therein, part or parts of which are also applicable to evaporative and motive purposes."—30th January 1852.

18. To John Chatterton, of Birmingham, in the county of Warwick, agent, "certain improvements in protecting insulated electro-telegraphic wires, and in the methods and machinery used for that purpose."—30th January 1852.

19. To Francis Clark Mouatis, of Earlston, in the county of Berwick, builder, "an improved hydraulic syphon."—4th February 1852.

20. To Sydney Smith, of Nottingham, "improvements in indicating the height of water in steam boilers."—4th February 1852.

21. To George Duncan, of the New North Road, Haxton, and Arthur Hutton, of the same place, "improvements in the manufacture of casks."—6th February 1852.

22. George Collier, of Halifax, in the county of York, mechanic, "improvements in the manufacture of carpets and other fabrics."—10th February 1852.

23. To Alfred Vincent Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, mechanical draughtsman, "improvements in the manufacture of pigments or paints."—11th February 1852.

24. To Charles Cowper, of 20 Southampton Buildings, Chancery Lane, in the county of Middlesex, patent agent, "improvements in machinery for combing and preparing wool and other fibrous substances;" being a communication.—13th February 1852.

25. To Alfred Vincent Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, mechanical draughtsman, "improvements in machinery for weaving coach lace, Brussels tapestry, and velvet carpeting, and other pile fabrics;" being a communication.—13th February 1852.

26. James Anderson Young, of the firm of A. S. Young and Son, of 185 Buchanan Street, Glasgow, in the county of Lanark, North Britain, surgeon-dentist, "certain improvements in dental operations, and in apparatus or instruments to be used therein."—16th February 1852.

27. To Hermann Turck, of Broad Street Buildings, in the city of London, merchant, "improvements in the manufacture of rosin oil;" being a communication.—18th February 1852.

28. To James Robertson, of Oxford Street, in the city of Manchester, chemist, "improved methods of producing or obtaining printing dyes and other substances used in printing, which improvements, in whole or in part, are applicable to other like useful purposes."—20th February 1852.

29. To William Hamer, of Manchester, in the county of Lancaster, "certain improvements in looms for weaving."—23d February 1852.

30. To Peter Armande le Comte de Fontaine Moreau, of 4 South Street, Finsbury, London, and 24 Boulevard Poissonniere, patent agent, "certain improvements in gas-burners;" being a communication.—26th February 1852.

31. To Charles John Mare, of Blackwall, "improvements in constructing iron ships or vessels, and steam-boilers."—1st March 1852.

32. To Henry Glynn, of Brunton Street, Berkeley Square, gentleman, and Rudolph Appel, of Gerrard Street, Soho, anastatic printer, "improve-

ments in the manufacture or treatment of paper or fabric to prevent copies or impressions being taken of any writing or printing thereon."—1st March 1852.

33. To William Edward Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, civil engineer, "improvements in the heddles or harness of looms for weaving, and in the machinery for producing the same;" being a communication.—2d March 1852.

34. To Henry Bessemer, of Baxter House, Old St Pancras Road, in the county of Middlesex, "improvements in expressing saccharine fluids, and in the manufacture, refining, and treating sugar."—3d March 1852.

35. To Frederick Crace Calvert, of Manchester, in the county of Lancaster, professor of chemistry and analytical chemist, "improvements in manufacturing iron, and in manufacturing and purifying coke."—4th March 1852.

36. To John Henry Johnson, of 47 Lincoln's Inn Fields, in the county of Middlesex, and of Glasgow, North Britain, gentleman, "improvements in weaving carpets and other fabrics, and in the machinery or apparatus employed therein."—4th March 1852.

37. To William Sinclair, of Manchester, in the county of Lancaster, engineer, "certain improvements in locks."—8th March 1852.

38. To John Blair, of Irvine, in the county of Ayr, North Britain, gentleman, "certain improvements in beds or couches, and other articles of furniture."—9th March 1852.

39. To Perry G. Gardner, of the city of New York, in the United States of America, civil engineer and mechanist, "improvements in the manufacture of malleable metals into pipes, hollow shafts, railway wheels, or other analogous forms, which are capable of being dressed, turned down, or polished in a lathe."—10th March 1852.

40. To Alfred Vincent Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, mechanical draughtsman, "improvements in machinery for combing wool and other fibrous substances;" being a communication.—15th March 1852.

41. To Alexander Cunninghame, of Glasgow, in the county of Lanark, North Britain, ironmaster, "improvements in the treatment and application of slag, or the refuse matter of blast furnaces."—15th March 1852.

42. To William Charles Scott, of Camberwell, in the county of Surrey, gentleman, "certain improvements in the construction of omnibuses, and other public and private carriages."—15th March 1852.

43. To William Stirling Lacon, of Great Yarmouth, in the county of Norfolk, gentleman, "improvements in the means of suspending ships' boats, and of lowering the same into the water."—16th March 1852.

44. To John Mercer, of Oakenshaw, Clayton-le-Moors, chemist; and John Greenwood, of Irwell Springs, Bacup, Turkey-red dyer, both in the county of Lancaster, "certain improvements in preparing cotton, and other fabrics, for dyeing and printing."—17th March 1852.

45. To Charles Middleton Kernot, of West Cowes, in the Isle of Wight, M.D.; and William Hirst, of Manchester, in the county of

Lancaster, manufacturer, "certain improvements in the manufacture woollen cloth, and cloth made from wool and other materials, and i machinery or apparatus for manufacturing the same."—17th Marc 1852.

46. To John Ramsbottom, of New Mills, in the county of Derby engraver, "certain improvements in machinery, or apparatus for measuring and registering the flow of water, and other fluids or vapours, which machinery or apparatus is also applicable to registering the speed of, and distance run by vessels in motion, and also in obtaining motive power and other similar purposes."—19th March 1852.

47. To William Pidding, of the Strand, in the county of Middlesex, gentleman, "improvements in mining operations, and in the machinery or apparatus connected therewith."—22d March 1852.

48. To Emanuel Charles Theodore Crontelle, manufacturer, of Rheims, in the republic of France, "certain improvements in machinery or apparatus for preparing woollen threads, and other filamentous substances for weaving."—22d March 1852.

49. To Edward Mosley Parkins, of Mark Lane, in the city of London, "improvements in the manufacture of cast-metal pipes, retorts, or other hollow castings."—22d March 1852.

50. To Charles Barlow, of 89 Chancery Lane, London, Esq., "improvements in rotary engines;" being a communication.—22d March 1852.

51. To William Symington, of Trafalgar Place, West Hackney Road, in the county of Middlesex, gentleman; and Charles Finlayson, of Manchester, engineer, and John Reid, of the same place, gentleman, "improvements in flues, and in heating air, and in evaporating certain liquids by heated air."—22d March 1852.

52. To John Wallace Duncan, of Grove End Road, Saint John's Wood, in the county of Middlesex, gentleman, "improvements in engines for applying the power of steam, or other fluids, for impelling purposes, and in the manufacture of appliances for transmitting motion."—22d March 1852.

53. To James Joseph Brunet, of the Canal Iron-Works, Poplar, in the county of Middlesex, engineer, "certain improved combinations of materials in ship-building;" communicated to him by Lucien Armand, of Bordeaux, France.—22d March 1852.

54. To Richard Archibald Brooman, of the firm of J. C. Robertson and Company, of 166 Fleet Street, in the city of London, patent agents, "improvements in presses and pressing, in centrifugal machinery, and in apparatus connected therewith, part or parts of which are applicable to various useful purposes;" being a communication.—24th March 1852.

55. To Colin Mather, of Salford, in the county of Lancaster, machine-maker, and Ernest Rolffs, of Cologne, in the kingdom of Prussia, gentleman, "certain improvements in printing, damping, stiffening, opening, and spreading woven fabrics."—24th March 1852.

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END OF VOLUME FIFTY-TWO.

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